

National Park Service
U.S. Department of the Interior

Natural Resource Program Center



Rocky Mountain National Park

Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory Digital Geologic Data
for Rocky Mountain National Park

romo_geology.pdf

Version: 3/1/2013

Geologic Resources Inventory Map Document for Rocky Mountain National Park

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Geologic Resources Inventory Map Document



Rocky Mountain National Park, Colorado

Document to Accompany Digital Geologic-GIS Data

[romo_geology.pdf](#)

Version: 3/1/2013

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Rocky Mountain National Park, Colorado (ROMO).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

National Park Service (NPS) Geologic Resources Inventory (GRI) Program staff have assembled the digital geologic-GIS data that accompanies this document.

For information about the status of GRI digital geologic-GIS data for a park contact:

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About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the Earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: <http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm>

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

GRI geologic-GIS data is also available online at the NPS Data Store site <http://science.nature.nps.gov/nrdata/>. To find GRI data select "geology" as a Category, and use "GRI" as a Word Search term.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: <http://www.nature.nps.gov/geology/inventory>, or contact:

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The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) program. For more information on the Inventory and Monitoring (I&M) program visit: <http://science.nature.nps.gov/im/index.cfm>

For more information on this and other Inventory and Monitoring (I&M) Natural Resource inventories visit: <http://science.nature.nps.gov/im/inventory/index.cfm>

GRI Digital Map and Source Map Citation

The GRI digital geologic-GIS map for Rocky Mountain National Park, Colorado (ROMO):

GRI Digital Geologic Map of Rocky Mountain National Park and Vicinity, Colorado (*GRI MapCode ROMO*)

Braddock, William A. and Cole, James C., 1990, Geologic Map of Rocky Mountain National Park and Vicinity, Colorado, U.S. Geological Survey, Miscellaneous Investigations Series Map I-1973, 1:50,000 scale. (*GRI Source Map ID 141*)

Additional information pertaining to each source map is also presented in the GRI Source Map Information (ROMOMAP) table included with the GRI geology-GIS data.

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Rocky Mountain National Park, Colorado (ROMO) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., mf - Manmade fill). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the Geologic Unit Information (ROMOUNIT) table included with the GRI geology-GIS data.

Cenozoic Era

Quaternary Period

[mf](#) - Manmade fill (Holocene)
[Qf](#) - Roaring River alluvial fan deposit (Holocene)
[Qd](#) - Holzwarth debris-flow deposit (Holocene)
[s](#) - Snow and ice (Holocene)
[Qa](#) - Alluvium (Holocene and upper Pleistocene)
[Qo](#) - Organic-rich sediment (Holocene and upper Pleistocene)
[Qc](#) - Colluvium (Holocene and Pleistocene)
[Ql](#) - Landslide deposits (Holocene and upper Pleistocene)
[Qt](#) - Talus (Holocene and upper Pleistocene)
[Qr](#) - Rock glacier (Holocene and upper Pleistocene)
[Qh](#) - Till (Holocene)
[Qp](#) - Till of Pinedale age (upper Pleistocene)
[Qb](#) - Till of Bull Lake age (upper Pleistocene)
[Qpb](#) - Till of pre-Bull Lake age (Pleistocene)
[Qg](#) - Gravel deposits on benches and terraces (Pleistocene)
[QNd](#) - Diamicton (Quaternary or Neogene)

Tertiary Period

[Tt](#) - Troublesome Formation (lower Miocene and upper Oligocene)
[Tc](#) - Coalmont Formation (Eocene and Paleocene)
[Ts](#) - Sedimentary rocks, undivided (Tertiary)
[Ta](#) - Trachyandesite and basalt (upper Oligocene)
[Tbr](#) - Volcanic breccia (upper Oligocene)
[Tr](#) - Rhyolite (upper Oligocene)
[Trw](#) - Rhyolite welded tuff (upper Oligocene)
[Taw](#) - Andesite welded tuff (upper Oligocene)
[Tv](#) - Volcanic rocks, undivided (upper Oligocene)
[Ti](#) - Intrusive rocks, undivided (Tertiary)
[Trp](#) - Rhyolite porphyry (upper Oligocene)
[Tib](#) - Basalt (upper? Oligocene)
[Tit](#) - Intrusive tuff (upper? Oligocene)
[Tql](#) - Quartz latite (upper Oligocene)
[Tqbr](#) - Quartz latite breccia (upper Oligocene)
[Tg](#) - Rhyolite porphyry and granite of the Mount Cumulus stock (upper Oligocene)
[Tgd](#) - Granodiorite and monzonite of the Mount Richthofen stock (upper Oligocene)
[Tap](#) - Andesite porphyry (upper? Oligocene)

Mesozoic Era

Cretaceous Period

[Kp](#) - Pierre Shale (Upper Cretaceous)

[Kn](#) - Niobrara Formation (Upper Cretaceous)

[Kb](#) - Benton Shale (Upper and Lower Cretaceous)

[Kd](#) - Dakota Formation (Lower Cretaceous)

Jurassic Period

[Jm](#) - Morrison Formation (Upper Jurassic)

[Js](#) - Sundance Formation (Upper and Middle Jurassic)

[Jms](#) - Morrison and Sundance Formations (Upper and Middle Jurassic)

Mesozoic and Paleozoic Eras

[TRPc](#) - Chugwater Formation (Lower Triassic and Upper Permian)

[MZu](#) - Sedimentary and metamorphic rocks, undivided (Mesozoic)

Paleozoic Era

Devonian Period

[Dk](#) - Kimberlite (Devonian?)

Precambrian - Proterozoic

[Yg](#) - Gabbro of the Iron Dike (Middle Proterozoic)

[Ysp](#) - Silver Plume Granite (Middle Proterozoic)

[Ysgg](#) - Garnet-sillimanite granite (Middle Proterozoic)

[Ylg](#) - Leucogranite (Middle Proterozoic)

[Yap](#) - Granite aplite (Middle Proterozoic)

[Ysb](#) - Intrusion breccia (Middle Proterozoic)

[Ygh](#) - Granite of Hagues Peak (Middle Proterozoic)

[Yd](#) - Mafic dikes (Middle Proterozoic)

[Ybg](#) - Biotite-muscovite granite (Middle? Proterozoic)

[Yqd](#) - Quartz diorite (Middle? Proterozoic)

[Xbc](#) - Boulder Creek Granodiorite (Early Proterozoic)

[Xt](#) - Trondhjemite of Thompson Canyon (Early Proterozoic)

[YXp](#) - Pegmatite (Middle and Early Proterozoic)

[Xs](#) - Biotite schist (Early Proterozoic)

[Xgf](#) - Microcline-biotite-quartz-plagioclase granofels (Early Proterozoic)

[Xh](#) - Hornblende gneiss and amphibolites (Early Proterozoic)

[Xcg](#) - Calc-silicate gneiss (Early Proterozoic)

[Xbh](#) - Biotite schist and hornblende gneiss (Early Proterozoic)

[Xgg](#) - Granitic gneiss (Early Proterozoic)

[Xlg](#) - Leucocratic gneiss (Early Proterozoic)

[YXu](#) - Proterozoic rocks, undivided (Early Proterozoic)

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below.

mf - Manmade fill (Holocene)

Major highway fill, earthdams, and dumps from tunnel and canal excavations. *GRI Source Map ID 141* ([L-1973](#)).

Qf - Roaring River alluvial fan deposit (Holocene)

Sediment ranging from very large boulders to silt deposited by flash flood of July 15, 1982, caused by failure of Lawn Lake dam. Thickness varies from 14 m to a few centimeters at mapped edge, average thickness 1.6 m (Jarrett and Costa, 1986). *GRI Source Map ID 141* ([L-1973](#)).

Qd - Holzwarth debris-flow deposit (Holocene)

Lobate deposit of mud, sand, and gravel deposited by mudflow of June 16, 1978, west side of Kawuneeche Valley north of Baker Gulch. Flow was initiated at altitude of 10,200 ft. when about 85 m³ of water-saturated debris occupying an area of about 28 m² suddenly began to slide. The sliding mass accelerated, incorporated more saturated debris, liquified, and flowed to base of slope within a few minutes. Track of debris flow varies from about 12 to 30 m wide. Within track all trees were removed and, in places, 30 cm of soil was scoured away. Trees were pushed to edge of track and piled. Surface flow of water down the track has produced deep gullies. Track of a similar debris flow that occurred between 1969 and 1974 is present in Baker Gulch. Debris from this flow apparently has been removed below where it entered Baker Creek. *GRI Source Map ID 141* ([L-1973](#)).

s - Snow and ice (Holocene)

Includes 34 snow banks and ice masses show on 1:24,000-scale topographic maps published between 1957 and 1962. All but one of these masses are on east side of Continental Divide; the exception is the mass above Murphy Lake. All but one occur at the heads of north-, northeast-, or east-facing cirques; the exception is the large snowbank northeast of Rowe Mountain, which is in a northeast-facing gully. Fourteen of the ice masses have been named: Rowe Glacier between Rowe and Hagues Peak; Sprague Glacier at Irene Lake in Spruce Canyon; Tyndall Glacier at head of Tyndall Creek; Andrews Glacier east of Andrews Pass; Taylor Glacier at head of Icy Brook; Chiefs Head Peak glacier above Frozen Lake; Mills Glacier on east side of Longs Peak; Moomaw Glacier south of The Cleaver; the six St. Vrain Glaciers at head of Middle St. Vrain Creek. Some of the ice masses (as Andrews Glacier) are actively moving, but some may be stagnant. It is not know whether the masses (over a long period of time) are growing or shrinking. *GRI Source Map ID 141* ([L-1973](#)).

Qa - Alluvium (Holocene and upper Pleistocene)

Gravel, sand, and silt along courses of major and intermittent streams, and in alluvial fans along valley margins. Includes small bodies of till. Also includes unstratified deposits of fine sand or silt southeast of Shadow Mountain Dam believed to be of eolian origin (Meierding, 1977, pages 41). Deposits of considerable thickness occur in major river valleys upstream from terminal moraines of Pinedale age: 15-25 m in Horseshoe Park and Moraine Park determined by drilling (Welder, 1971); 15-122 m in Kawuneeche Valley and 53 m in Big Meadows determined by seismic study (R.A. McCullough, oral commun., 1974). These thick deposits may contain lake sediments deposited behind dams formed by

terminal moraines. Lake sediments composed of gray-blue clay interlayered with peat are exposed in stream cuts in Big Meadows (Meierding, 1977, pages 42). Several bodies of alluvium were deposited at margins of lateral moraines (as in Hidden Valley) when streams were dammed by the moraines. These deposits may contain lake sediments and alluvium of Pinedale and Bull Lake age. *GRI Source Map ID 141* ([I-1973](#)).

Qo - Organic-rich sediment (Holocene and upper Pleistocene)

Bog deposits estimated to be less than 8m thick. Deposits are probably of later Pinedale age or younger. *GRI Source Map ID 141* ([I-1973](#)).

Qc - Colluvium (Holocene and Pleistocene)

Deposits of rock debris ranging in size from silt to boulders, formed by a variety of mass-wasting processes. Includes older talus, slope wash deposits, solifluction deposits, block fields, and nivation scree. Although most slopes are mantled by a thin layer of colluvium and contain only scattered exposures of bedrock, colluvium has been mapped only in those areas where it is several meters thick or where it covers large areas and obscures the continuity of bedrock units. *GRI Source Map ID 141* ([I-1973](#)).

Ql - Landslide deposits (Holocene and upper Pleistocene)

Includes slumps and earth flows of till on north side of Lake Granby and along sides of Kawuneeche Valley; large, nearly intact masses of volcanic rocks between Iron Mountain and Bald Mountain; jumbled, hummocky masses or relatively intact blocks of Proterozoic rocks; and slumps of sedimentary rocks and colluvium along west side of map area. The large slide on Jackstraw Mountain is composed of biotite schist ([Xs](#)). The foliation in the schist around the slide area dips to the north and northwest, about parallel to the direction the slide moved. *GRI Source Map ID 141* ([I-1973](#)).

Qt - Talus (Holocene and upper Pleistocene)

Angular blocks of rock and abundant interstitial smaller rock fragments on steep slopes and at base of cliffs; accumulated primarily by rock falls. Includes some deposits transported by debris flow and by snow avalanche. Most talus is Holocene. *GRI Source Map ID 141* ([I-1973](#)).

Qr - Rock glacier (Holocene and upper Pleistocene)

Lobate mass of rock debris ranging in size from large blocks to silt. Veneered by boulders. Characterized by steep front and hummocky, commonly furrowed, upper surface that slopes at a relatively low angle. Rock material accumulated principally as talus, but later was mobilized and flowed away from original accumulation site. Ability to flow probably requires interstitial ice or ice core. Some rock glaciers accumulated principally at heads of cirques and flowed down length of main valley, whereas others accumulated along sides of a valley and flowed outward toward center. Most rock glaciers are Holocene, some are still active. They occur at altitudes from 9,600 to 12,200 ft, are abundant on both sides of Continental Divide and on both sides of Never Summer Mountains, and have flowed down slopes that face all compass directions. *GRI Source Map ID 141* ([I-1973](#)).

Qh - Till (Holocene)

Fresh to slightly weathered, stoney, sandy till mainly forming small end moraines near headwalls of cirques. Rocks on surface are angular; soil development is weak to absent. Tills were deposited by small glaciers that advanced short distances several times during the last 10,000 years (Meierding and Birkeland, 1980, pages 170). Distribution of these tills is very similar to that of existing snow and ice masses. *GRI Source Map ID 141* ([I-1973](#)).

Qp - Till of Pinedale age (upper Pleistocene)

Subangular to subrounded boulders, cobbles, and pebbles set in a sandy silt to silty sand matrix. Prominent, sharp-crested moraines are numerous; rugged knob-and-kettle topography is well developed in some areas. Gullying is negligible. Moraine-dammed lakes, swamps, and perennial kettle-hole ponds are abundant. Most soils (A and B horizons only) are 45-75 cm thick. Less than 5 percent of stones in B horizon are rotted. Description from Gable and Madole (1976). Patterned lines within unit indicate trend of lateral and terminal moraines. Pinedale glaciation probably began in the region more than 35,000 years ago, and occurred in several pulses. Last major advance of Pinedale glaciers approached its maximum about 22,000 years ago, and these glaciers began to recede from their terminal moraines between 13,000 and 15,000 years ago. Most Pinedale glaciers were probably gone by 10,000-11,000 years ago (age data from Madole and Shroba, 1979, pages 128-129). *GRI Source Map ID 141* ([I-1973](#)).

Qb - Till of Bull Lake age (upper Pleistocene)

Subangular to subrounded boulders, cobbles, and pebbles in a silty sand matrix. Morainal form subdued in comparison to till of Pinedale age ([Qp](#)). Undrained depressions on this till are uncommon and it is more weathered than till of Pinedale age. Soils are 1-2 m thick. Thirty to 70 percent of stones in B horizon of soil are partially to totally rotted. Description from Gable and Madole (1976) and Meierding (1977). Patterned lines within unit indicate trend of moraines. South and southwest of Shadow Mountain Lake, the till is partly mantled by sheet-like deposits of fine sand or silt believed to be of eolian origin (Meierding, 1977, pages 41). Till of Bull Lake age may have been deposited between about 130,000 and 150,000 years ago (Madole and Shroba, 1979, pages 130). *GRI Source Map ID 141* ([I-1973](#)).

Qpb - Till of pre-Bull Lake age (Pleistocene)

Boulders and cobbles in a silty sand matrix. Deposits lack morainal form and have thick, reddish-brown, clayey soil containing abundant rotted granitic clasts. Age very poorly known-possibly deposited between 400,000 and 550,000 years ago (Madole and Shroba, 1979, pages 133). *GRI Source Map ID 141* ([I-1973](#)).

Qg - Gravel deposits on benches and terraces (Pleistocene)

Stratified deposits of rounded to subrounded cobbles, pebbles, and sand of pre-Bull Lake age. *GRI Source Map ID 141* ([I-1973](#)).

QNd - Diamicton (Quaternary or Neogene)

Unsorted, unstratified deposits of boulders, cobbles, and pebbles in a silty sand matrix. Deposit on Blue Ridge contains some boulders as large as 4.5 m, although boulders as large as 3 m are more common. Boulders of this deposit are composed of granitic and pegmatitic rock of Proterozoic age; many cobbles and pebbles are composed of biotite schist; a few sandstone cobbles may have been derived from the Dakota Formation ([Kd](#)). No fragments of Tertiary igneous rocks were observed. Deposit located 5 km

west of Cameron Pass is very poorly exposed. Here, subrounded to well-rounded boulders, as large as 2 m, are composed mostly of Proterozoic granitic rocks; some fine-grained sandstone cobbles might be from the Dakota or Sundance Formations ([Js](#)). No fragments of Tertiary igneous rocks were observed. Three poorly exposed deposits occur in Tahosa Valley; the ground surface is littered with boulders as large as 1.5 m. Deposit near Meeker Campground appears to be a fan deposit. The northernmost deposit (near Alpine Brook) was believed to be a pre-Bull Lake till by Richmond (1960, pages 1373). *GRI Source Map ID 141* ([I-1973](#)).

Tt - Troublesome Formation (lower Miocene and upper Oligocene)

Gray and orange-gray, tuffaceous mudstone and sandstone, volcanic ash beds, and minor clayey limestone and conglomerate. Contains several interlayered basaltic lava flows ([Ta](#)). Thin basal conglomerate on northeast shore of Lake Granby contains cobbles of mafic to silicic Tertiary volcanic rocks and resistant Proterozoic rocks. Formation covers a surface of considerable relief (as much as 200 m at Chickaree Lake) and rests unconformably on rocks that are Late Cretaceous to Early Proterozoic in age. Sparse exposures from Shadow Mountain Lake northward to Chickaree Lake, on both sides of the Kawuneeche Valley, indicate that at least the southern part of this valley existed prior to deposition of the Troublesome Formation ([Ti](#)). K-Ar and fission-track dates on volcanic ash and interlayered basalt indicate that lower part of formation was deposited in this area between 23 and 29 Ma (Izett, 1975; R.L. Drake, written commun., 1982). *GRI Source Map ID 141* ([I-1973](#)).

Tc - Coalmont Formation (Eocene and Paleocene)

Gray to brown, fine- to medium-grained, arkosic sandstone, dark-gray carbonaceous mudstone, and conglomerate containing clasts as large as 1.5 m. Clasts in coarse conglomerate are mostly resistant Proterozoic rocks; some finer conglomerate contains abundant clasts of mafic to intermediate Tertiary volcanic rocks. Occurs only in northwest corner of map area and unconformably overlies the Niobrara or Benton Formations ([Kn](#) or [Kb](#)). About 525 m of lower part is preserved in syncline, but top is not exposed. *GRI Source Map ID 141* ([I-1973](#)).

Ts - Sedimentary rocks, undivided (Tertiary)

Small exposures of sedimentary rocks that interfinger with or underlie Oligocene volcanic deposits south of Peterson Park, west of Long Draw Reservoir, between Thunder Mountain and Iron Mountain, and northeast of Specimen Mountain on the ridge between Willow Creek and the Cache la Poudre River. These rocks, probably Oligocene in age, include blocky-weathering, orange-pink, tan, or light-gray tuffaceous mudstone, conglomeratic sandstone containing pebbles or cobbles of Tertiary volcanic rocks, and fine-grained vitric tuff. Other small exposures of sedimentary rocks that do not contain volcanic detritus occur from Phantom Creek on Trail Ridge Road northward to Crater Gulch, and beneath the volcanic rocks just west of Iceberg Lake. These rocks, possibly early Tertiary in age, include pebbly mudstone, fine-grained sandstone, siltstone, micritic limestone, and clayey boulder conglomerate containing clasts of resistant Proterozoic rocks as much as 1 m in diameter. *GRI Source Map ID 141* ([I-1973](#)).

Ta - Trachyandesite and basalt (upper Oligocene)

Dark-gray, very fine grained rock that weathers to grayish brown, grayish purple, or moderate red. Interlayered with the Troublesome Formation in southwest part of map area, and with other volcanic rocks in northwest part. Phenocrysts constitute a trace to as much as 40 percent; plagioclase is the most abundant phenocryst, and biotite, amphibole, pyroxene, olivine, and sanidine occur in varying amounts. Moderate to abundant potassium feldspar occurs in groundmass of trachyandesite. Textures

are commonly trachytic, subtrachytic, or dense and vesicular. Rocks are commonly altered and contain iron oxides, chlorite, and carbonate minerals. Ten analyzed samples had SiO₂ contents in the 51-64 percent range. *GRI Source Map ID 141* ([I-1973](#)).

Tbr - Volcanic breccia (upper Oligocene)

Massive to layered breccia containing fragments a few centimeters to 10 m long. On Seven Utes Mountain, interlayered volcanic breccia and laharic breccia contain blocks of Mesozoic sedimentary rock, Proterozoic gneiss, andesitic to quartz monzonitic intrusive rocks, and glassy extrusive rocks. Matrix of volcanic breccia is weakly to strongly flow banded, glassy to devitrified. East of the lowest of the Michigan Lakes, breccia is composed of biotite quartz monzonite and lesser amounts of monzonite, quartz-bearing monzodiorite, rhyolite, and hornfels. The quartz monzonite resembles that in the stock of Mount Richthofen ([Tgd](#)). South of Thunder Pass, the unit has monolithologic quartz monzonite breccia at base; polymictic breccia of gneiss, schist, andesite, and rhyolite above; and fine-grained volcanic sandstone at top. *GRI Source Map ID 141* ([I-1973](#)).

Tr - Rhyolite (upper Oligocene)

White, light-gray, pale-yellowish-brown, moderate-brown, or pale-red-purple, well-laminated rock. Contains 5-10 percent phenocrysts that are dominantly sanidine with some plagioclase and minor quartz or oxidized biotite. Groundmass is cryptocrystalline and massive, or finely flow laminated, or locally devitrified as radial intergrowths of feldspar and quartz. Lamination in the flows is typically contorted, and fold amplitudes range between a few centimeters to as much as 30 m. Principal occurrence is north and east of Iron Mountain, where flows apparently issued onto a topographic surface with more than 300 m of relief. Rhyolite flows also occur in small areas on east side of Kawuneeche Valley (in part resting on Troublesome Formation ([Ti](#))) and near Apiatan Mountain. *GRI Source Map ID 141* ([I-1973](#)).

Trw - Rhyolite welded tuff (upper Oligocene)

Strongly welded, weakly layered gray, black, or brown crystal-rich tuff containing sparse to abundant fragments of volcanic rock and Proterozoic schist and gneiss. Contains about 30 percent crystals of sanidine, quartz, oligoclase, and minor biotite in a wholly glassy to moderately devitrified matrix. Strongly compacted pumice fragments are common, but shard texture is generally not recognizable. Deposit on Seven Utes Mountain comprises an ascending sequence of unwelded ash, vitrophyre, densely welded and devitrified tuff, and moderately welded and devitrified tuff (O'Neill, 1981). *GRI Source Map ID 141* ([I-1973](#)).

Taw - Andesite welded tuff (upper Oligocene)

Orange-pink, light-gray, or grayish-black crystal-vitric tuff. Contains about 45 percent crystals of plagioclase, clinopyroxene, biotite, opaque oxides, and traces of sanidine. Matrix is glass and varies from densely welded and laminated with no visible shards to strongly welded with abundant shards and pumice fragments. Crops out only in one small area between Trap Creek and Corral Creek. *GRI Source Map ID 141* ([I-1973](#)).

Tv - Volcanic rocks, undivided (upper Oligocene)

Major rock types within this unit are: rhyolite lava flows and welded to non-welded rhyolite ash flows; debris-flow deposits containing cobbles and boulders of Tertiary volcanic rocks and Proterozoic gneiss and schist; and tuff, which is altered in places to bentonite. Unit locally contains andesite flows or fine-grained sandstone composed of Tertiary volcanic detritus. *GRI Source Map ID 141* ([I-1973](#)).

Ti - Intrusive rocks, undivided (Tertiary)

Dikes, sills, and small plugs; typically very fine grained or altered; composition roughly estimated from proportions of sparse to abundant phenocryst minerals. Numerous bodies with abundant phenocrysts in northwest part of map area include andesite, latite, quartz latite, dacite, or rhyolite porphyries in the form of steep-walled dikes and plugs; probably of late Oligocene age, based on age of major intrusions in this part of map area. Latite-andesite and dacite intrusions are typical near Longs Peak and to the south, where these rocks form flat-lying sheets as well as steeply dipping dikes and plugs; age may range from Eocene to latest Cretaceous, based on age of nearby major intrusions to the south (Gable, 1980). Dike at Red Deer Lake (southwest of St. Vrain Mountain) has been dated as 52.6 $\pm$ 5.6 Ma (Pearson, 1980, p. 20), or early Eocene. *GRI Source Map ID 141* ([I-1973](#)).

Trp - Rhyolite porphyry (upper Oligocene)

White, tan, or light-reddish-brown porphyritic rock containing 20-40 percent phenocrysts of quartz, sanidine, oligoclase, biotite, and brown hornblende in aphanitic groundmass. Small exposures in Kawuneeche Valley west of Green Mountain Ranch have steep flow layering, and may be the margin of a stock that extends west to North Supply Creek. Zircon from the small stock near Porphyry Peaks has a fission-track age of 25.9 $\pm$ 2 Ma (average of analyses 50 and 51 of Marvin and others, 1974, p. 9). *GRI Source Map ID 141* ([I-1973](#)).

Tib - Basalt (upper? Oligocene)

Dark-gray to black, dense rock that forms an isolated plug about 4 km west of north end of Lake Granby. *GRI Source Map ID 141* ([I-1973](#)).

Tit - Intrusive tuff (upper? Oligocene)

Yellowish-gray to grayish-green, poorly sorted tuff consisting of volcanic dust, ash, and lapilli, and containing comminuted Proterozoic rocks, sparse siltstone and sandstone of possible Mesozoic age, and Oligocene igneous rocks (mainly latite and trachyandesite). Forms a singular pipe-like body west-northwest of Bowen Mountain (Metzger, 1974); margin of pipe is a zone that grades inward from oxidized and fractured Proterozoic wall rock to blocky breccia of wall rock (with dikelets of tuff) to bedded tuff. Exposures in center of pipe are poor; bedding appears to dip 10 degrees - 50 degrees inward and is cut by thin cataclastic zones that strike north-northwest and dip steeply northeast. Tuff is cut by dikes ([Ti](#)) of latite and quartz latite of probable late Oligocene age. *GRI Source Map ID 141* ([I-1973](#)).

Tql - Quartz latite (upper Oligocene)

Gray to brownish-gray porphyry containing about 25 percent phenocrysts of oligoclase-andesine (as much as 3 cm long), sanidine, and minor biotite and clinopyroxene in a microcrystalline groundmass that is rich in potassium feldspar. Zircons from this rock have a fission-track age of 28.4 $\pm$ 2.9 Ma (Izett, 1974). Quartz latite probably intrudes lower part of the Troublesome Formation ([Ti](#)), but is nonconformably overlain in places by middle part of the Troublesome. *GRI Source Map ID 141* ([I-1973](#)).

Tqbr - Quartz latite breccia (upper Oligocene)

Brown to reddish-brown monolithologic breccia; locally grades into quartz latite ([Tql](#)); breccia is probably mostly extrusive. Occurs only about 4 km northwest of Lake Granby. *GRI Source Map ID 141* ([I-1973](#)).

Tg - Rhyolite porphyry and granite of the Mount Cumulus stock (upper Oligocene)

Massive light-brown to reddish-orange rock composed of orthoclase microperthite, quartz, oligoclase, and minor biotite. Most of central part of stock is holocrystalline, dense to very fine grained rhyolite porphyry that contains abundant phenocrysts of microperthite and quartz, 0.3-10.0 mm in diameter, less common oligoclase, and minor biotite. North, east, and south margins of stock consists of fine- to medium-grained, equigranular granite (maximum grain size approximately 5 mm). Unit Tg intrudes the granodiorite stock of Mount Richthofen ([Tgd](#)). Zircon fission-track ages for the rhyolite and granite are 28.2+/-0.7 Ma and 28.8+/-1.5 Ma, respectively (Gamble, 1979, p. 54). *GRI Source Map ID 141* ([I-1973](#)).

** Occurrence of dominantly equigranular granite [indicated by stippled areas on source paper map].

Tgd - Granodiorite and monzonite of the Mount Richthofen stock (upper Oligocene)

Light- to medium-gray; outer parts of stock consist of massive, equigranular to slightly porphyritic granodiorite composed of andesine, potassium feldspar, quartz, hornblende, biotite, and minor clinopyroxene; inner part of stock consists of monzonite and quartz monzonite composed of zoned plagioclase, potassium feldspar, and hornblende, and minor quartz, biotite, and augite. Mount Richthofen stock intrudes andesite porphyry ([Tap](#)) and trachyandesite ([Ta](#)) along Box Canyon. K-Ar age determination on biotite indicates stock is 29.5+/-1.5 Ma (Corbett, 1968, p. 8). *GRI Source Map ID 141* ([I-1973](#)).

Tap - Andesite porphyry (upper? Oligocene)

Dark-gray to black, massive rock that contains abundant yellowish-white andesine phenocrysts; and less common orthopyroxene, clinopyroxene, biotite, and hornblende in a partly glassy to cryptocrystalline matrix. *GRI Source Map ID 141* ([I-1973](#)).

Kp - Pierre Shale (Upper Cretaceous)

Interbedded silty shale and sandstone overlying dark-gray to black shale. Lower 500 m of formation, poorly exposed north of Porphyry Peaks, contains fossils identified as *Inoceramus subcompressus* Meek and Hayden, *Didymoceras* sp., and *Baculites gilberti* Cobban (W.A. Cobban, written commun., 1974); lower formation, exposed southwest of site of Willey Lumber Camp on south side of Michigan River, contains *Baculites obtusus* Meek (O'Neill, 1976, p. 39). Adjacent to the Mount Richthofen stock, the Pierre has been thermally metamorphosed to dense, hard, medium- to dark-gray hornfels that weathers yellowish gray. Metamorphic minerals (biotite, epidote-clinozoisite, chlorite, and muscovite) indicate metamorphism to albite-epidote hornfels facies (O'Neill, 1976, p. 34). O'Neill (1976, pages 39-40) correlated this hornfels at Nokhu Crags with the Terry and Hygiene Sandstone Members of the Pierre, and reported *Inoceramus barabini* Morton from the upper and middle sections. *GRI Source Map ID 141* ([I-1973](#)).

Kn - Niobrara Formation (Upper Cretaceous)

Light- to dark-gray calcareous shale. Occurs in small patches in northwest, west, and southwest parts of map area. *GRI Source Map ID 141* ([I-1973](#)).

Kb - Benton Shale (Upper and Lower Cretaceous)

Consists of three informal subunits; topmost beds of fossiliferous limestone and underlying very fine grained sandstone (thickness about 12 m total) contain fossils of Juana Lopez age (Late Cretaceous); middle unit is medium-gray calcareous shale (thickness about 60 m); lower unit is medium- to dark-gray non-calcareous shale (thickness about 46 m). *GRI Source Map ID 141* ([I-1973](#)).

Kd - Dakota Formation (Lower Cretaceous)

Light-gray to light-brown, very fine grained to fine-grained, ripple-marked, thin- to very thick bedded sandstone; locally conglomeratic; local trace fossils (tracks and burrows) in upper part; light-gray to light-brown lenticular conglomeratic sandstone and chert pebble conglomerate in lower part; thickness varies from about 25 to 75 m. *GRI Source Map ID 141* ([I-1973](#)).

Jm - Morrison Formation (Upper Jurassic)

Green, greenish-gray, and grayish-red silty claystone, light-gray sandstone, and a few thin, discontinuous beds of dense limestone; thickness about 90 m. *GRI Source Map ID 141* ([I-1973](#)).

Js - Sundance Formation (Upper and Middle Jurassic)

Buff very fine grained sandstone and laminated siltstone, probably equivalent to the Canyon Springs Sandstone Member; about 40 m thick. *GRI Source Map ID 141* ([I-1973](#)).

Jms - Morrison and Sundance Formations (Upper and Middle Jurassic)

Formations combined in southwest part of map area; Morrison Formation ([Jm](#)) about 91 m thick; Sundance Formation ([Js](#)) about 18 m thick. *GRI Source Map ID 141* ([I-1973](#)).

TRPc - Chugwater Formation (Lower Triassic and Upper Permian)

Reddish-brown to orange-red shale, siltstone, and fine-grained sandstone; laminated to thin bedded; contains detrital mica; thickness 180-240 m near Cameron Pass; thickness not determined in southwest part of map area. Lower part of Cameron Pass section contains light-gray to white finely laminated limestone (possible Forelle Limestone Member of Late Permian age), 1-2 m thick, above reddish-brown sandy and silty shale that is 0-8 m thick. Formation contains lenticular limestone (maximum thickness 1 m) at base in southwest part of map area. *GRI Source Map ID 141* ([I-1973](#)).

MZu - Sedimentary and metamorphic rocks, undivided (Mesozoic)

Dark-gray hornfels at Thunder Pass, and red-brown to gray-green sandstone and biotite-bearing hornfels on north side of Mount Nimbus; may be Cretaceous or Jurassic. *GRI Source Map ID 141* ([I-1973](#)).

Dk - Kimberlite (Devonian?)

Dark-gray or dark-olive-green, altered, fragmental rock within small dikes at three isolated localities. Y-shaped dike about 2 km east of Rams Horn Mountain contains pale-golden-yellow biotite, small grains of purplish-red garnet, ilmenite, and numerous 5- to 15-mm grains that appear to be chlorite pseudomorphs of pyroxene, within porous calcitic matrix. In Hayden Gorge northeast of Hayden Spire, talus blocks consist of rounded nodules as large as 3 cm in a hard silicified matrix. Centers of nodules are

aggregates of talc(?) that are veined by quartz. Rims of nodules consist of very fine grained quartz, dark-green biotite, and iron oxides. Matrix surrounding the nodules contains sparse grains of red garnet and bright-green pyroxene, both mantled by talc(?), very fine grained green biotite, iron oxides, and abundant secondary quartz. In upper East Inlet approximately 2 km west of Isolation Peak, a 15 cm thick dike, approximately 7 m long, consists of rounded clasts as large as 1.2 cm in diameter in a matrix of fine-grained calcite and pale-yellow biotite. Clasts are aggregates of quartz with complex texture of unknown origin, or chlorite that is partly replaced by calcite. Kimberlite occurs at a number of localities in the Front Range (Smith and others, 1979), and was probably emplaced during Devonian time (Chronic and others, 1969; Naeser and McCallum, 1977). *GRI Source Map ID 141* ([I-1973](#)).

Yg - Gabbro of the Iron Dike (Middle Proterozoic)

Dark-gray to black ferrogabbro; weathers dark brown to orange brown; limonite stains prominent along joint surfaces. Forms en echelon dikes in a nearly continuous line from the southeast corner of map area to Long Draw Reservoir. Chilled dike margins consist of sparse plagioclase and augite phenocrysts in a dense groundmass; dike centers are medium grained, ophitic, and contain labradorite, augite, titaniferous magnetite, and traces of quartz, microcline, and biotite. Petrography described in detail by Wahlstrom (1956) and Cole (1977). Rb-Sr age determinations indicate dikes were intruded 1,317 $\pm$ 50 Ma (Z.E. Peterman, written commun., 1986). *GRI Source Map ID 141* ([I-1973](#)).

Ysp - Silver Plume Granite (Middle Proterozoic)

Light- to medium-gray, grayish-orange, orange-pink, or red-purple monzogranite to syenogranite that contains characteristic tabular microcline phenocrysts. Equigranular matrix is locally fine, medium, or coarse grained, and proportion of phenocrysts is variable throughout the region; flow alignment strong in rocks with abundant phenocrysts. Average mineral composition is similar regardless of texture, and contains 30 percent quartz, 25-28 percent oligoclase, 32-35 percent microcline, 7 percent biotite, trace amounts of magmatic garnet and sillimanite, 1 percent subsolidus muscovite, and minor apatite, monazite, and magnetite. Irregular-shaped outcrop masses in east and central parts of map area form northwest part of the composite Longs Peak-St. Vrain batholith, which extends south to Ward and east to Lyons, Colorado, over an area of more than 1,200 km². Granite bodies forming the north, northeast, and south parts of batholith generally have steep walls, are sharply discordant, and are characterized by gradual transitions between internal textural varieties. In contrast, granite bodies forming the southwest part of batholith (along Continental Divide) were emplaced as anastomosing, flat-lying sheets that are largely concordant with foliation in the surrounding, gently dipping metamorphic rocks. Silver Plume exposed in the Glacier Gorge-Chiefs Head Peak-Longs Peak-Mount Meeker-Estes Cone region consists of sharply bounded granite sheets that vary in color, texture, or composition, and that are locally separated by thin sheets of metamorphic rock. Granite exposed west of Wild Basin is compositionally more homogeneous, but is surrounded by zones of metamorphic rocks that contain 10-75 percent intrusive sheets or irregular bodies of granite (indicated by pattern on older rocks). Age of the Silver Plume Granite in the Longs Peak-St. Vrain batholith is 1,420 $\pm$ 25 Ma (Peterman and others, 1968, p. 2289). Several rock types that are believed to be related to the Silver Plume Granite have been mapped in local areas. *GRI Source Map ID 141* ([I-1973](#)).

Ysgg - Garnet-sillimanite granite (Middle Proterozoic)

Light-grayish-pink or grayish-yellow, medium- to coarse-grained, xenomorphic-granular syenogranite composed of quartz, microcline perthite, oligoclase, and accessory magmatic garnet, sillimanite, and biotite. Mapped only between Ouzel Peak and Copeland Mountain, but small bodies are also present near Mount Lady Washington (Cole, 1977, p.60). This granite also forms numerous sills in biotite schist along a zone approximately 1 km wide and 2 km long between Junco and Bluebird Lakes. *GRI Source Map ID 141* ([I-1973](#)).

Ylg - Leucogranite (Middle Proterozoic)

Pink, weakly foliated rock composed of quartz, microcline, oligoclase, and minor biotite; mapped in two bodies west of Lead Mountain, Never Summer Mountains. *GRI Source Map ID 141* ([I-1973](#)).

Yap - Granite aplite (Middle Proterozoic)

Cream to buff, fine- to medium-grained, xenomorphic-granular rock composed of quartz, oligoclase, microcline, and minor magmatic sillimanite. Two bodies exposed along West Creek, 7 km north of Lake Estes, grade into pegmatite along contact between Silver Plume Granite ([Ysp](#)) and biotite schist ([Xs](#)). *GRI Source Map ID 141* ([I-1973](#)).

Ysb - Intrusion breccia (Middle Proterozoic)

Irregular dikes, sheets, and pipe-like bodies that contain about 75 percent rounded to angular fragments of biotite schist, pegmatite, amphibolite, and medium-grained Silver Plume Granite ([Ysp](#)) in a fine-grained, biotite-rich granitic matrix. Fragments range from a few centimeters to 30 m in diameter. Breccia intrudes Silver Plume in general, but is also intruded by dikes of fine- and medium-grained Silver Plume Granite. Mapped only in a 1.5 km by 0.5 km body on east flank of Stones Peak; smaller masses near entrance road junction at Hidden Valley ski area and near The Sharkstooth in Loch Vale are not shown on map. *GRI Source Map ID 141* ([I-1973](#)).

Ygh - Granite of Hagues Peak (Middle Proterozoic)

Tan, coarse-grained to very coarse grained porphyritic granite composed of quartz, microcline, oligoclase, and biotite. Contains flow-aligned phenocrysts of microcline 2-8 cm long, and scattered, small, partially assimilated inclusions of biotite schist that contain large porphyroblasts of microcline. The Granite of Hagues Peak is crosscut by the Silver Plume Granite ([Ysp](#)), and yields a whole-rock Rb-Sr isochron age of 1,480 Ma (C.E. Hedge, written commun., 1977). *GRI Source Map ID 141* ([I-1973](#)).

Yd - Mafic dikes (Middle Proterozoic)

Black to light-gray, fine- to medium-grained metabasalt or meta-andesite. Four subvertical dikes exposed northeast of the North Fork Big Thompson River consists of blastoporphyrictic biotite quartz diorite or hornblende-biotite quartz diorite, and correlate with dikes in a north- to northwest-trending swarm that is widely exposed east and north-east of map area; this swarm cuts 1,430-Ma-old Sherman Granite (Zielinski and others, 1981) and is cut by 1,420-Ma-old Silver Plume Granite ([Ysp](#)). Lensoid, dismembered fragments of similar dike rock are contained as conformable masses within biotite schist between Hayden Gorge and Glacier Gorge, and consist of schistose, plagioclase-porphyritic hornblende-biotite quartz diorite. Intense deformation and disruption are interpreted to have resulted from rock flowage that accompanied emplacement of the Silver Plume Granite (Cole, 1977). *GRI Source Map ID 141* ([I-1973](#)).

Ybg - Biotite-muscovite granite (Middle? Proterozoic)

Light-gray to tan, fine- to medium-grained, equigranular, xenomorphic, nonfoliated to weakly foliated granite that contains quartz, oligoclase, microcline, biotite, and muscovite; forms two small plugs and a folded (?) sill in northeast corner of map area. *GRI Source Map ID 141* ([I-1973](#)).

Yqd - Quartz diorite (Middle? Proterozoic)

Fine- to medium-grained, medium- to dark-gray, nonfoliated rock composed of oligoclase-andesine, hornblende and (or) biotite, and quartz. Scattered porphyroblasts of microcline are present in bodies that are surrounded by the Granite of Hagues Peak ([Ygh](#)) in the North Fork Big Thompson River; other small masses are mapped in Fall River Canyon south of McGregor Mountain and in East Inlet near Mount Cairns. (I-1973; Braddock and Cole, 1990). *GRI Source Map ID 141* ([I-1973](#)).

** Areas where numerous dikes of Silver Plume Granite ([Ysp](#)) intrude quartz diorite (Yqd) [indicated by stippled regions on source paper map].

Xbc - Boulder Creek Granodiorite (Early Proterozoic)

Light- to medium-gray, medium- to coarse-grained, weakly to strongly foliated granodiorite composed of oligoclase, quartz, microcline, and 5-15 percent biotite; phenocrysts of microcline (1-4 cm long) common. Forms a large elongate pluton in south-central part of map area, and small bodies 4 km northeast of Lake Estes, 1 km east of Lead Mountain (Never Summer Mountains), and in southeast corner of map area. Rb-Sr age for Boulder Creek Granodiorite in plutons southeast and northeast of map area is 1,664 $\pm$ 40 Ma (Peterman and others, 1968, p. 2287). *GRI Source Map ID 141* ([I-1973](#)).

** Areas where numerous dikes of Silver Plume Granite ([Ysp](#)) intrude Boulder Creek Granodiorite [indicated by stippled regions on source paper map].

Xt - Trondhjemite of Thompson Canyon (Early Proterozoic)

Light-gray, medium-grained, weakly foliated rock composed of albite-oligoclase, quartz, biotite, and sparse microcline; forms three irregular bodies near Signal Mountain northeast of Estes Park. U-Pb analysis of zircon from a pluton east of map area indicates an age of 1,726 $\pm$ 15 Ma (Barovich, 1986, p. 40). *GRI Source Map ID 141* ([I-1973](#)).

YXp - Pegmatite (Middle and Early Proterozoic)

White, medium-grained to very coarse grained pegmatite composed primarily of quartz, microcline-perthite, and albite and less abundant muscovite, garnet, and (or) tourmaline. Small pegmatite lenses are widespread in biotite schist ([Xs](#)), but only large or conspicuous intrusions are shown on map; Middle Proterozoic pegmatite, formed late during crystallization of Silver Plume Granite ([Ysp](#)), and Early Proterozoic pegmatite, related to Boulder Creek Granodiorite ([Xbc](#)), are both present but cannot be distinguished by field examination; small pegmatite lenses formed by partial melting during peak metamorphism of biotite schist. *GRI Source Map ID 141* ([I-1973](#)).

Xs - Biotite schist (Early Proterozoic)

Conspicuously banded rock marked by alternating layers of contrasting composition; dark-gray to black, medium- to coarse-grained layers are rich in biotite, sillimanite, and magnetite; light- to medium-gray or bluish-gray, fine-grained layers contain more quartz and feldspar than biotite; white, coarse-grained layers consist of quartz and feldspar and minor biotite. Weathers to mottled reddish or yellowish brown. Layering is typically folded into moderate warps and tight flexures and isoclines. Protolith consisted of alternating beds of shale, siltstone, and sandstone. Regional metamorphism at about 1,700 Ma (Peterman and others, 1968, p. 2284) produced characteristic mineral assemblages that vary across the region depending on maximum local temperature and pressure. Northeast of the North Fork Big Thompson River, maximum temperature of metamorphism was as low as 525 degrees C (J.W. Drexler,

oral commun., 1986), partial melting was not initiated (migmatite is absent), and the typical prograde assemblage consists of quartz, plagioclase, lepidoblastic muscovite, biotite, staurolite, andalusite, and iron oxides. Throughout most of map area, peak temperatures probably exceeded 700 degrees C (Nesse, 1977, 1984), anatectic melting was widespread (migmatite is ubiquitous), and typical mineral assemblage contains quartz, plagioclase, microcline, sillimanite, biotite, +/- garnet, +/- cordierite, hercynite, and iron oxides. Presence of garnet (rare) and (or) cordierite depends on local bulk composition; prograde cordierite appears to have formed by reactions of the type: biotite + sillimanite = cordierite + anatectic melt. Mineral changes between the lower and higher temperature regions are shown by the red dashed-line boundaries: sillimanite is present west of the S boundary, whereas staurolite and andalusite disappear near this boundary; microcline appears and lepidoblastic muscovite disappears at the K boundary; migmatite appears south and west of the M boundary; cordierite is present south and east of an unmapped, broad zone that extends from Eagle Rock (north of Estes Park) through Beaver Meadows, Mount Wuh, Ptarmigan Mountain, and southwestward to the east end of Granby Reservoir. *GRI Source Map ID 141* ([I-1973](#)).

** Areas where numerous sills, dikes, or irregular bodies of Silver Plume Granite ([Ysp](#)) intrude biotite schist ([Xs](#)) [indicated by stippled regions on source paper map]. Areas that contain numerous conformable layers of pegmatite ([YXp](#)) [indicated by crossed regions on source paper map].

Xgf - Microcline-biotite-quartz-plagioclase granofels (Early Proterozoic)

Fine- to medium-grained, light- to medium-gray, granoblastic to semischistose rock that commonly contains garnet and sillimanite. Includes thin unmapped layers of biotite schist ([Xs](#)) and amphibolite ([Xh](#)). *GRI Source Map ID 141* ([I-1973](#)).

Xh - Hornblende gneiss and amphibolites (Early Proterozoic)

Fine- to medium-grained, medium- to dark-gray, weakly to strongly layered rocks composed primarily of hornblende, plagioclase, and quartz. *GRI Source Map ID 141* ([I-1973](#)).

** Areas that contain numerous conformable layers of pegmatite ([YXp](#)) [indicated by crossed regions on source paper map].

Xcg - Calc-silicate gneiss (Early Proterozoic)

Light-gray to cream, weakly to moderately foliated gneiss composed of andesine, microcline, quartz, and diopside. Mapped only near Baker Mountain, southern Never Summer Mountains. *GRI Source Map ID 141* ([I-1973](#)).

Xbh - Biotite schist and hornblende gneiss (Early Proterozoic)

Mapped only where biotite schist ([Xs](#)) and hornblende gneiss ([Xh](#)) are finely interlayered. *GRI Source Map ID 141* ([I-1973](#)).

Xgg - Granitic gneiss (Early Proterozoic)

Light- to medium-gray, fine- to coarse-grained, weakly foliated rock composed principally of quartz, oligoclase, and biotite. Microcline is generally present but amount varies from sparse to abundant; hornblende, garnet, and rare sillimanite or orthopyroxene are locally present. *GRI Source Map ID 141* ([I-1973](#)).

** Areas where numerous sills, dikes, or irregular bodies of Silver Plume Granite ([Ysp](#)) intrude granitic gneiss (Xgg) [indicated by stippled regions on source paper map].

Xlg - Leucocratic gneiss (Early Proterozoic)

Light-gray, fine-grained to very coarse grained rock containing contorted, wispy layers of biotite schist; only mapped north of Long Draw Reservoir. *GRI Source Map ID 141* ([I-1973](#)).

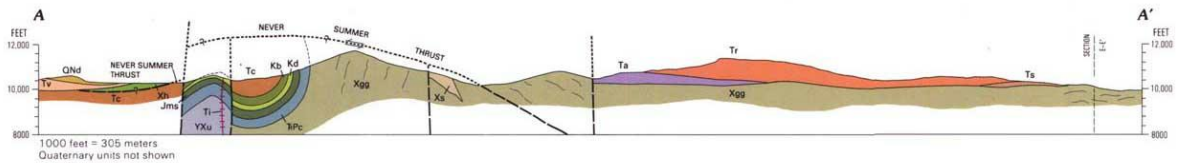
YXu - Proterozoic rocks, undivided (Early Proterozoic)

Shown in cross sections only. *GRI Source Map ID 141* ([I-1973](#)).

Geologic Cross Sections

The geologic cross sections present in the GRI digital geologic-GIS data produced for Rocky Mountain National Park, Colorado (ROMO) are presented below. Cross section graphics were scanned at a high resolution and can be viewed in more detail by zooming in (when viewing the digital format of this document).

A-A'



Rocky Mountain NP

I-1973: Geologic Cross Section A-A'

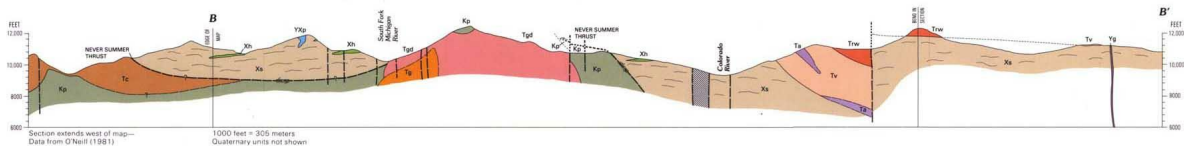
Geologic Map of Rocky Mountain NP and Vicinity, Colorado

by William A. Braddock and James C. Cole

U.S. Geological Survey, 1990

Extracted from: GRI Source Map ID 141 ([I-1973](#)).

B-B'



Rocky Mountain NP

I-1973: Geologic Cross Section B-B'

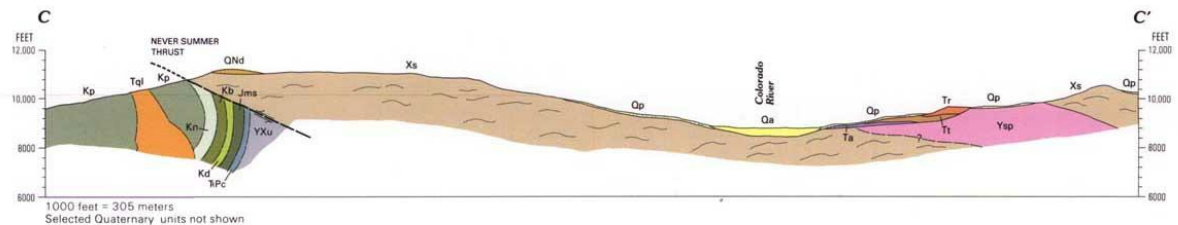
Geologic Map of Rocky Mountain NP and Vicinity, Colorado

by William A. Braddock and James C. Cole

U.S. Geological Survey, 1990

Extracted from: GRI Source Map ID 141 ([I-1973](#)).

C-C'



Rocky Mountain NP

I-1973: Geologic Cross Section C-C'

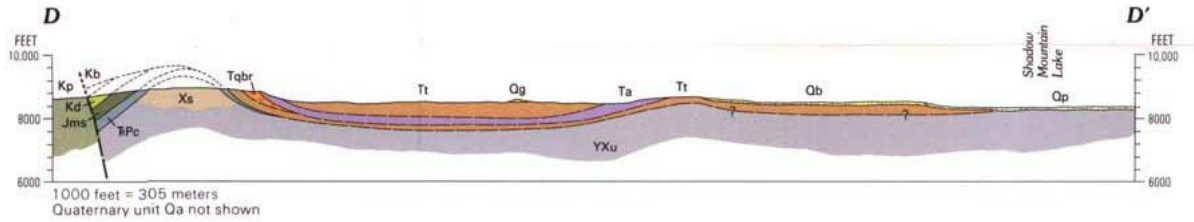
Geologic Map of Rocky Mountain NP and Vicinity, Colorado

by William A. Braddock and James C. Cole

U.S. Geological Survey, 1990

Extracted from: GRI Source Map ID 141 ([I-1973](#)).

D-D'



Rocky Mountain NP

I-1973: Geologic Cross Section D-D'

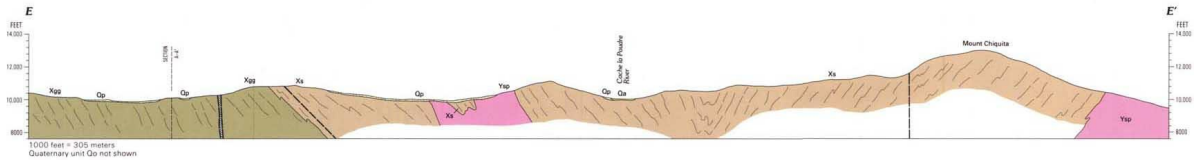
Geologic Map of Rocky Mountain NP and Vicinity, Colorado

by William A. Braddock and James C. Cole

U.S. Geological Survey, 1990

Extracted from: GRI Source Map ID 141 ([I-1973](#)).

E-E'



Rocky Mountain NP

I-1973: Geologic Cross Section E-E'

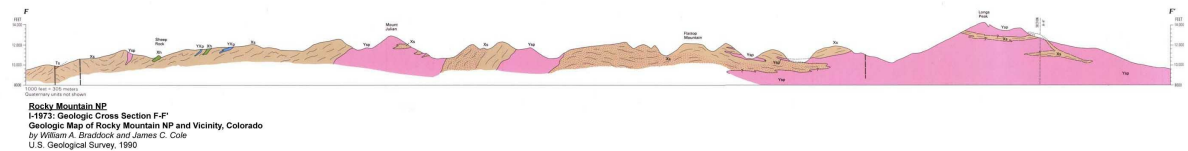
Geologic Map of Rocky Mountain NP and Vicinity, Colorado

by William A. Braddock and James C. Cole

U.S. Geological Survey, 1990

Extracted from: GRI Source Map ID 141 ([I-1973](#)).

F-F'



Rocky Mountain NP

I-1973: Geologic Cross Section F-F'

Geologic Map of Rocky Mountain NP and Vicinity, Colorado

by William A. Braddock and James C. Cole

U.S. Geological Survey, 1990

Extracted from: GRI Source Map ID 141 ([I-1973](#)).

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CORRELATION OF MAP UNITS

QUATERNARY

- Holocene: Qf, Qd, Qa, Qo, Qc, Ql, Qt, Qr, Qh, Qp, Qb, Qpb, Qg
- Pleistocene: QNd

QUATERNARY OR NEOGENE

TERTIARY

- lower Miocene: Tq, Tqbr, Tg, Tgd, Tdp
- upper Oligocene: Tib, Tit
- Miocene: Tt
- Oligocene: Trp, Trb, Trv, Taw, Tv
- Eocene: Ts
- Paleocene: Tc

CRETACEOUS

- Upper Cretaceous: Kp, Kn
- Lower Cretaceous: Kb, Kd
- JURASSIC

 - Upper Jurassic: Jm
 - Middle Jurassic: Js, Jms
 - Lower Jurassic: Meu

TRIASSIC

- Lower Triassic: Tpc
- Upper Triassic: Tpc

DEVONIAN(?)

PROTEROZOIC

- Middle Proterozoic: Ysp, Ysgg, Yfg, Ydp, Ysb, YXp, Yd, Ybg, Yqd, Xbc, Xt
- Early Proterozoic: YXu

SEDIMENTARY AND METAMORPHIC

INTRUSIVE IGNEOUS

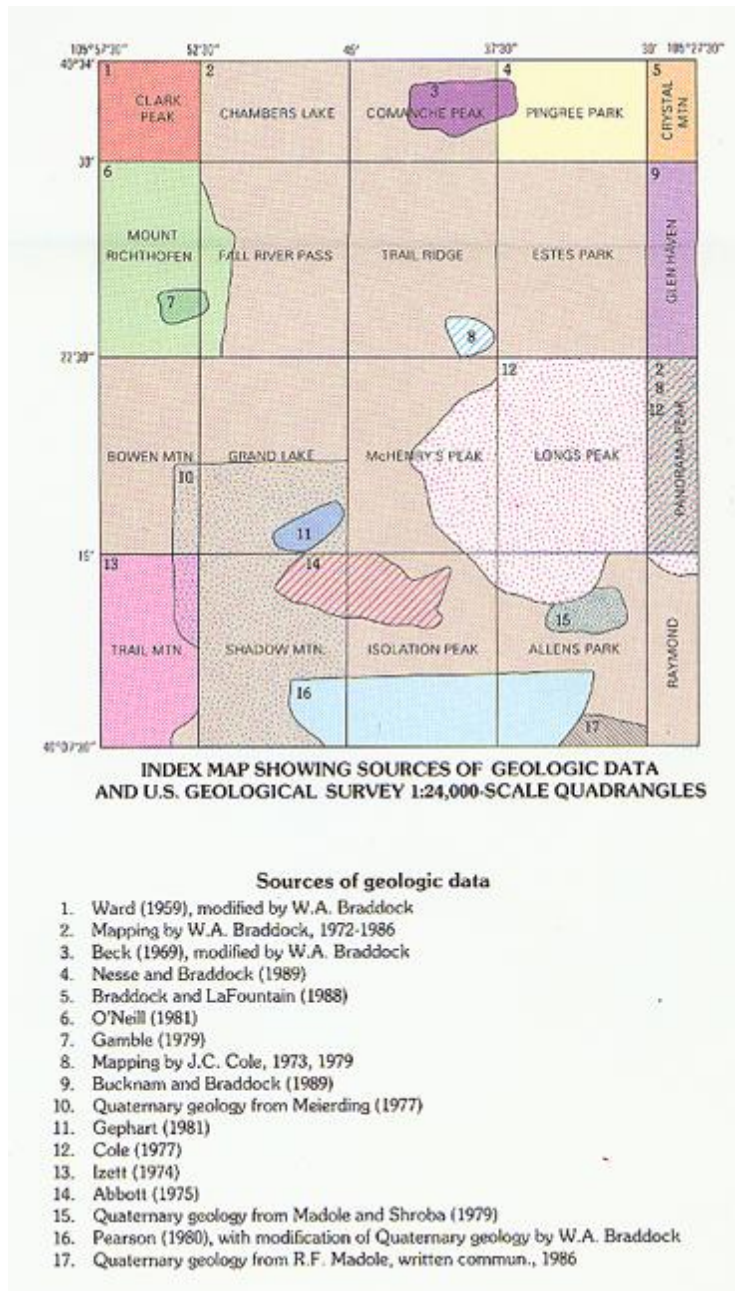
EXTRUSIVE IGNEOUS

SEDIMENTARY

METAMORPHIC

2013 NPS Geologic Resources Inventory Program

Sources of Geologic Data



Extracted from: GRI Source Map ID 141 ([I-1973](#)).

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The information contained here was compiled to accompany the digital geologic-GIS map and other digital data for Rocky Mountain National Park, Colorado (ROMO) developed by Stephanie O'Meara and Dave Green (Colorado State University) using an earlier GRI version of this digital geologic-GIS dataset initially produced from digital source CAD files provided by William Braddock, and from the digitization and attribution of features using the source paper map.

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