Isotopic Geochronology of the Leadville 1°×2° Quadrangle, West-Central Colorado—Summary and Discussion

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By ALAN R. WALLACE

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ISOTOPIC GEOCHRONOLOGY OF THE LEADVILLE 1°×2° QUADRANGLE, WEST-CENTRAL COLORADO—SUMMARY AND DISCUSSION

By Alan R. Wallace

ABSTRACT

More than 360 isotopic dates have been obtained by numerous workers from rocks in the Leadville 1°×2° quadrangle in west-central Colorado. The dates provide important information regarding the age of emplacement of Proterozoic, Late Cretaceous, and Tertiary igneous rocks. Some of the dates on the Proterozoic rocks in the quadrangle provide evidence regarding the actual age of Early and Middle Proterozoic intrusive activity, but most of the dates on those rocks reflect resetting by Phanerozoic tectonic and thermal events. Due largely to the absence of pre-Laramide Phanerozoic igneous activity, what little is known about the ages of tectonic events during that time is derived from dated stratigraphic correlations from outside the quadrangle.

The majority of the dates are Late Cretaceous and younger, reflecting extensive igneous, hydrothermal, and tectonic events during that time. Igneous activity spanned much of the Tertiary but was most intense during the Laramide (about 73–52 Ma), middle Tertiary (44–30 Ma), and late Tertiary (28–1.6 Ma). In mineralized areas, such as the world-class Climax, Gilman, and Leadville deposits, dates show that many mineral deposits in the quadrangle are of middle Tertiary age and are related to specific intrusive systems. Fission-track dates on apatite and zircon have been used to determine the timing of Tertiary uplift of major horsts such as the Sawatch Range. Dates on basalt flows demonstrate major post-10-Ma tectonism and formation of the Colorado River drainage system.

Many of the dates on rocks from the quadrangle reflect partial to complete resetting by one or more subsequent thermal events. Some of these dates, when incorporated into a larger data base and placed into a geologic context, can provide useful information. However, many reset dates, especially when considered alone, have been used to arrive at erroneous geologic conclusions. Therefore, recognizing and understanding the variability in the data for specific units and events is an important first step in future geologic studies in the quadrangle.

INTRODUCTION

The rocks and structures of the Leadville 1°×2° quadrangle, in the mountains of west-central Colorado (figs. 1, 2), reflect a complex geologic history that spans the past 1.8 billion years. The quadrangle also contains a rich endowment of metallic mineral deposits. As a result, the geology and mineral deposits of the quadrangle have been the focus of numerous geologic studies related to regional geologic research and mineral exploration.

During the course of these and other investigations, many samples of a wide variety of rocks have been collected and dated, using various geochronologic techniques, to augment the broader research. Through mid-1994, more than 360 separate dates have been reported from rocks from the quadrangle. Other dates undoubtedly have been determined but not reported, and, although every effort was made to identify and include those dates in this compilation, some probably have been missed. The reported dates unfortunately are scattered throughout the literature, and only rarely has one data set been compared with others. Richard F. Marvin, of the U.S. Geological Survey, periodically compiled and published dates that had been reported in the literature or had been determined in the geochronology facilities of the USGS (Marvin and others, 1974; Marvin and Cole, 1978; Marvin and Dobson, 1979; Marvin and others, 1989), but many other dates were not included in these summaries. Also, many potassium-argon dates reported before 1977 do not reflect a change in isotopic constants (Steiger and Jäger, 1977) and therefore are too young by as much as several percent.

In an effort to enhance future studies in the quadrangle, all of the isotopic dates for the Leadville 1°×2° quadrangle that had been made available through mid-1994 have been compiled into the present data set. The data are presented in appendix A along with information regarding location, isotopic method and material used, date and analytical uncertainty, sources of data and related geology, relation to mineral deposits, and pertinent miscellaneous information. This table is available on diskette in a spreadsheet format

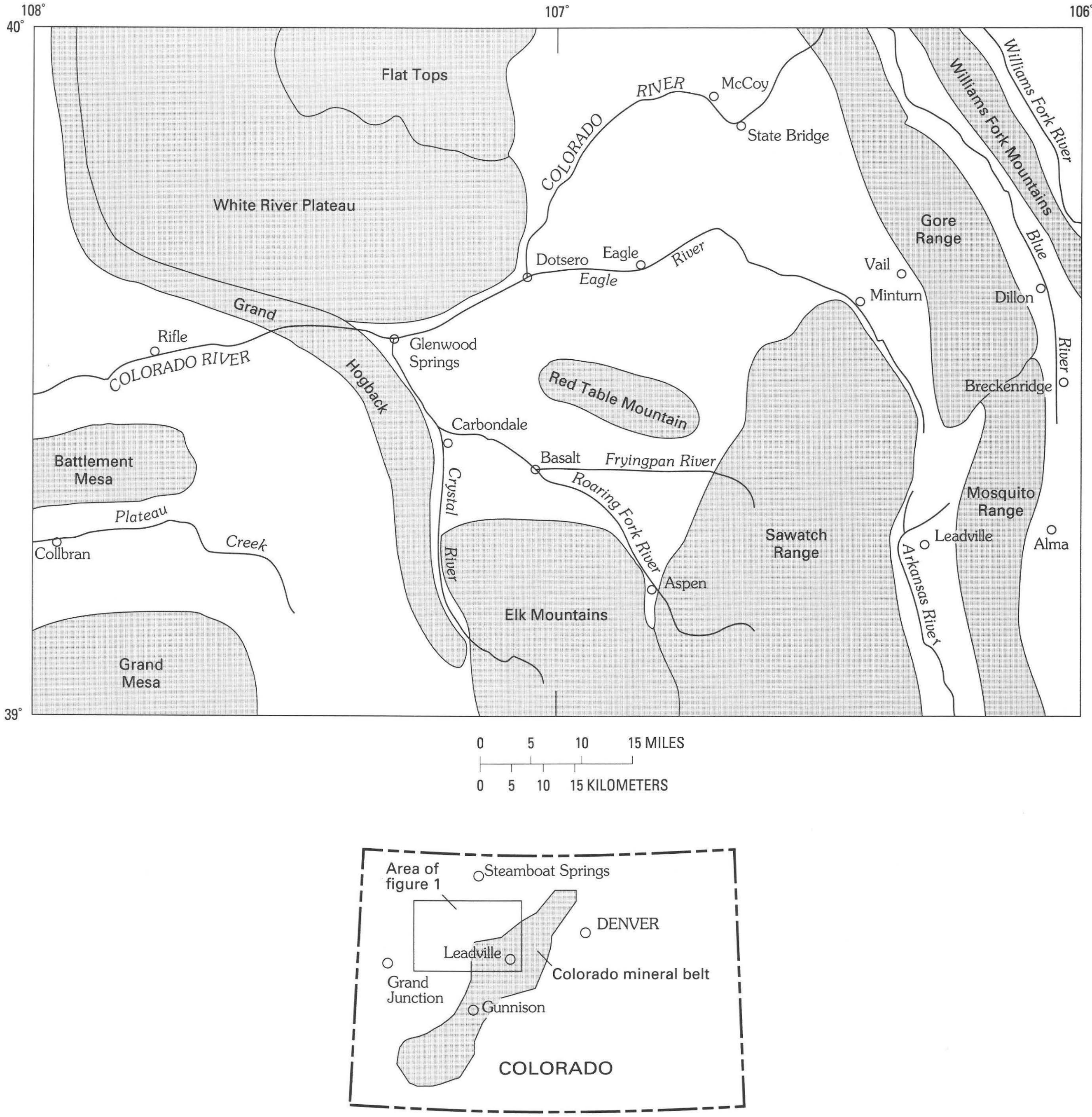


Figure 1. Major geographic features of the Leadville 1°×2° quadrangle, west-central Colorado (modified from Tweto and others, 1978).

(Wallace, 1993). The data also are presented in abbreviated form by (1) age (appendix B), (2) name of unit dated (appendix C), (3) geochronologic method (appendix D), and (4) mining district (appendix E).

All sample locations are shown on plate 1, with sample numbers increasing to the south. In some areas of closely spaced sampling, samples have been lumped into one site for the sake of clarity; exact coordinates are given in appendix A. Two samples (No. 1, rhyolite ash fall, and No. 350, Grand Mesa basalt) were collected just outside the boundaries of the quadrangle, but, because they date units that extend into the quadrangle, they are included in the compilation and shown on the edges of plate 1; exact coordinates are given in appendix A. Some sample locations on plate 1 do not correspond to the appropriate rock unit on the map. In part, this is due to (1) the compilation scale of the map, whereby the body dated was not large enough to be included on the map; (2) the unit not having been identified at the time of compilation, such as the Treasure Vault stock in the northern Sawatch Range (Wallace and others, 1986); or (3) an

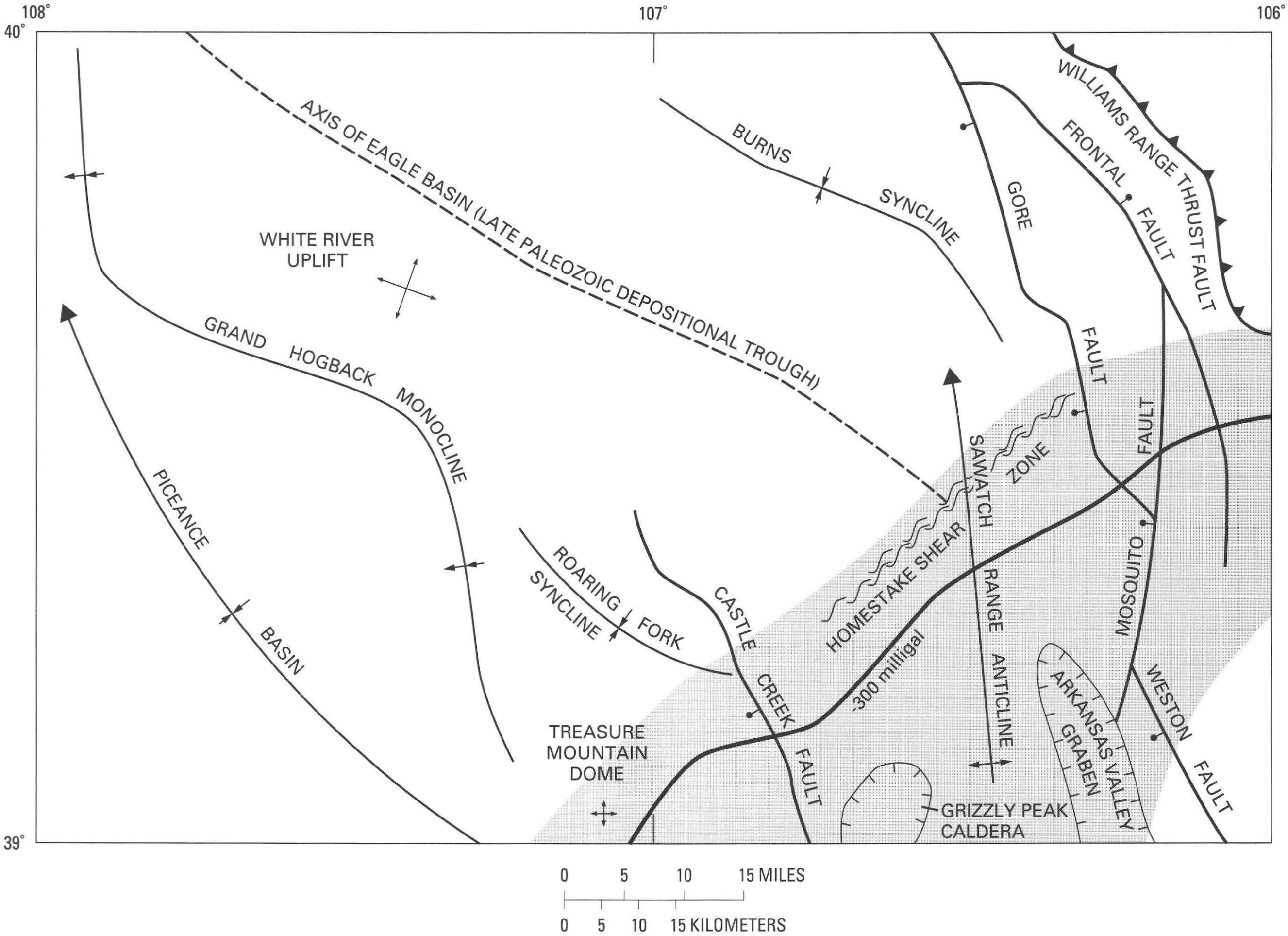


Figure 2. Major geologic features of the Leadville 1°×2° quadrangle. The heavy line delineates the –300-mGal contour of a major gravity low described by Tweto and Case (1972). Colorado mineral belt shaded gray.

incorrect latitude and longitude having been provided with the published date. In the last case, even though it is usually evident that the sample probably was collected from a nearby unit, no attempt has been made to modify the sample locations because, as noted above, the coordinates might actually pinpoint an outcrop that is too small to appear on the geologic map.

The geochronologic methods that have been used to date rocks in the quadrangle include potassium-argon (K-Ar), rubidium-strontium (Rb-Sr), uranium-thorium-lead (U-Th-Pb), carbon-14 (C-14), lead-alpha (Pb-alpha), neodymium-samarium (Nd-Sm), fission track (FT), and $^{40}Ar/^{39}Ar$. Information regarding the various geochronologic dating techniques can be obtained from Faure (1986). All K-Ar dates are reported using new constants; those originally calculated using the old constants have been recalculated using the tables provided by Dalrymple (1979). Most of the other dates, except as noted in appendix A or in the text, are reported as they appeared in the original source, despite some revisions in Rb-Sr and fission-track constants. Pearson and others (1966) reported Pb-alpha dates on zircons for several Proterozoic units in the Sawatch Range. This relatively early method of numerical dating has numerous assumptions, such as absence of lead and uranium loss and no inherited common lead, that subsequently were shown to be invalid, and the accuracy of these dates is unpredictable and therefore suspect. Therefore, although the dates of Pearson and others (1966) are included in this compilation for the sake of completeness, dates determined by other methods are more reliable and should be used instead.

ACKNOWLEDGMENTS

The data in this compilation were derived largely from the published literature and unpublished theses. Additional dates and information were provided by A.A. Bookstrom, E.H. DeWitt, M.W. Ganster, S.L. Ludington, C.W. Naeser, J.C. Reed, Jr., R.P. Smith, T.B. Thompson, and R.E. Zartman. Gary Selner provided guidance with computerized plotting routines (GSPOST) to generate plate 1. C.W. Naeser and A.A. Bookstrom reviewed the manuscript and, along with A.J. Donatich, all the mind-numbing tables.

GEOLOGIC SUMMARY

The geology of the Leadville 1°×2° quadrangle represents more than 1.8 billion years of active tectonism, extensive plutonism, and cratonic sedimentation. During that time, geologic processes created substantial accumulations of mineral and energy resources, some of which have been tapped and others that undoubtedly await discovery. The following summary draws from more detailed summaries, including Tweto (1977) and Wallace (1990), as well as the extensive published literature. The geology of the quadrangle was published in Tweto and others (1978), which is shown as the base for plate 1.

PROTEROZOIC GEOLOGY

METASEDIMENTARY AND METAVOLCANIC ROCKS

The metamorphic rocks in the quadrangle include interlayered gneiss, schist, and migmatite. Protoliths include graywacke, shale, basalt, and intermediate to felsic volcanic rocks. The volcanic and volcaniclastic rocks have a strong bimodal affinity, and trace-element modeling indicates a mantle-derived source for the basalts and a mixed mantle-crust source for the felsic volcanics (Boardman and Condie, 1986).

INTRUSIVE ROCKS

Granitic magmas were emplaced into the Early Proterozoic crust at approximately 1.7 and 1.4 Ga. The 1.7-Ga intrusive rocks include the Cross Creek Granite, the Denny Creek Granodiorite, the trondhjemitic Kroenke Granodiorite, and other unnamed granitic to dioritic rocks. The intrusive event was synorogenic to post-orogenic and related to arc magmatism. Ages range from about 1.71 to 1.66 Ga (Reed, 1986).

The 1.4-Ga intrusive rocks are represented by the peraluminous St. Kevin Granite and possibly by the age-equivalent Silver Plume Granite. This plutonic event was largely anorogenic, and the melts were derived from metasedimentary rocks in the lower crust (Anderson and Thomas, 1985).

METAMORPHISM AND STRUCTURE

The Early Proterozoic sedimentary and volcanic rocks were regionally metamorphosed to at least amphibolite grade and complexly deformed prior to and during the emplacement of the 1.7-Ga batholiths. The rocks are cut by numerous faults and shear zones having predominantly north-northwest and northeast trends. Although most of the north-northwest-trending faults initially formed in the Proterozoic, many of them, most notably the Gore fault, were reactivated during the Phanerozoic.

The northeast-trending fault system consists of the Homestake shear zone in the northern Sawatch Range, as well as similar structures in the Gore and Front Ranges (Tweto and Sims, 1963). The zone includes numerous individual faults having textures that range from gouge to mylonites, indicating a wide range of deformational environments, the more brittle of which probably developed during the Phanerozoic.

PALEOZOIC AND MESOZOIC GEOLOGY

Paleozoic and Mesozoic sedimentation in central Colorado responded to episodic epeirogenic and orogenic uplift and related transgressive-regressive marine and nonmarine cycles (De Voto, 1990). The total stratigraphic sequence is more than 13,000 m thick.

With the exception of pronounced orogenic uplift in the late Paleozoic, most of the Paleozoic and Mesozoic sedimentation and erosion in central Colorado were related to regional epeirogenic events. The north-northwest-trending Ancestral Front Range and northwest-trending Uncompahgre highland rose rapidly in the Middle Pennsylvanian, as Proterozoic faults were reactivated to form range-bounding faults.

CENOZOIC GEOLOGY

Cenozoic sedimentation and erosion, igneous and tectonic activity, and mineralization were complexly and intimately related. These geologic events define two major tectonic epochs: (1) the Laramide orogeny (latest Cretaceous through Paleocene time) and (2) late Cenozoic (Oligocene to present) activity. In addition, three peaks of igneous activity can be identified: separate Laramide and Oligocene subduction-related events, and Oligocene and younger continental (bimodal) activity accompanied by crustal extension.

LARAMIDE STRUCTURE AND STRATIGRAPHY

Following the retreat of the Late Cretaceous sea, basement blocks began to rise and orogenic sediments were shed into the adjacent basins. Plutonic and volcanic activity accompanied uplift. The north-trending Sawatch Range was the first of the major uplifts to develop. The Gore and Front Ranges began to form slightly later, reactivating older faults as well as generating new structures, such as the Williams Range thrust fault along the west side of the Williams Fork Mountains.

The White River uplift and the Grand Hogback were the last major Laramide structures to form. The White River uplift, a broad elongate dome, did not develop until early to middle Eocene time. The Grand Hogback marks a west- to south-dipping monocline that forms the western and southern flanks of the White River uplift; it extends southward into the Elk Mountains where it is cut by a 35-Ma pluton. With the exception of uplift of the White River and Grand Hogback structures, uplift waned in the late Paleocene and Eocene. Erosion and sedimentation gradually degraded the mountainous terrain until the topography was relatively gentle beneath a late Eocene erosion surface.

In the early to middle Eocene, lacustrine shales and marls and fluvial sandstones of the Green River Formation were deposited in and around a broad, shallow lake in western Colorado and eastern Utah. The Parachute Creek Member is noted for its oil shale reserves.

LARAMIDE AND OLIGOCENE IGNEOUS ACTIVITY

Subduction-related igneous rocks were emplaced during Laramide uplift from about 72 to 59 Ma, and again in the late Eocene and Oligocene from about 42 to 30 Ma. Activity was apparently restricted to a northeast-trending zone that is roughly coincident with the Colorado mineral belt (fig. 1). The intrusions form small to large stocks, sills, and dikes in Proterozoic to Cretaceous host rocks. Trace-element and isotopic data indicate that the magmas were derived from partial melting from the lower crust with a possible contribution of mantle material. Most of the Laramide plutons in the quadrangle are generally not genetically associated with ore deposits.

Most of the middle Tertiary (late Eocene and Oligocene) calc-alkaline igneous rocks are in the eastern and particularly the southern parts of the quadrangle. In the Elk Mountains, 34-Ma laccoliths intruded Phanerozoic sedimentary rocks. Volcanic edifices have largely been stripped away by erosion, although volcanic rocks are preserved in the 34-Ma Grizzly Peak cauldron near Independence Pass (Fridrich, 1986).

LATE CENOZOIC STRUCTURE AND SEDIMENTATION

Following a period of late Eocene and early Oligocene tectonic quiescence, uplift disrupted the nearly flat topography. Block faulting reactivated many Laramide and Proterozoic faults, renewing uplift of the Sawatch, Gore/Tenmile, Mosquito, and Front Ranges. Extensional faulting related to the north-northwest-trending Rio Grande rift (Tweto, 1977) longitudinally cut the east flank of the Laramide Sawatch uplift, creating the Mosquito and Sawatch Ranges and the intervening upper Arkansas River valley graben. Major movement along the Mosquito fault and reactivation of older faults generated the Gore/Tenmile Range and basins to the east and west.

Despite late Oligocene uplift in the eastern half of the quadrangle, significant Neogene deformation to the west did not commence until about 10 Ma. Renewed doming of the White River uplift began at this time, and orogenic activity continued in the ranges to the east.

A major period of Quaternary climatic cooling induced glaciation that continued from about 500,000 years ago into the Holocene. During three glacial maxima, ice almost totally covered the higher ranges, and the valleys were filled with glaciers; the modern alpine topography, characterized by deep U-shaped valleys, is largely a product of glacial erosion.

LATE CENOZOIC IGNEOUS ACTIVITY

With the change in the tectonic regime, igneous activity produced late Oligocene to Miocene anorogenic granites and Miocene and younger basalts. The high-silica granites range in age from about 33 Ma at Climax to 12 Ma at Treasure Mountain, and many are associated with major molybdenum deposits or prospects. Trace-element and isotopic data indicate that the anorogenic granites were derived from partial melting of the lower crust.

Basaltic flows ranging in age from 24 Ma to 4,150 years were erupted throughout the western half of the quadrangle (Larson and others, 1975; Giegengack, 1962). The basalts are part of a bimodal assemblage that includes small rhyolitic dikes and flows on the east side of the Flat Tops.

DISCUSSION OF ISOTOPIC DATES

The geochronologic data in appendix A generally fall into four groups. The first group includes the dates that reasonably reflect the actual ages of specific intrusive or mineralizing events. The second group includes those dates that are essentially unusable for reasons such as excess argon or lead. The third group is perhaps the most intriguing: it includes those ages that do not date the rocks from which they were derived, but rather date (or reflect) subsequent unrelated events. The futuristic fourth group comprises dates that have yet to be determined on important intrusive, mineralizing, and tectonic events. The discussion that follows considers all four groups within broad time frames. It is not meant to be an exhaustive review, but, by considering the data base as a whole, it hopefully will provide some coherence to the hundreds of dates in the quadrangle and provide some suggestions for future geochronologic work.

PROTEROZOIC DATES

The ages of Proterozoic igneous and metamorphic rocks and related tectonic events in the Leadville 1°×2° quadrangle are poorly documented, which is surprising considering their extensive exposures in the quadrangle. Proterozoic rocks shown on the geologic map of the quadrangle (Tweto and others, 1978) correlate with Early Proterozoic metasedimentary and metavolcanic rocks, and with Early and Middle Proterozoic intrusive rocks exposed and dated elsewhere in Colorado (Tweto, 1977; Bickford, 1988; Reed and others, 1987).

The protoliths for the Early Proterozoic metasedimentary and metavolcanic rocks in Colorado were deposited between about 1,770 and 1,700 Ma (Bickford, 1988; Reed and others, 1987). A Nd-Sm age of 1,800±90 Ma (DePaolo, 1981) indicates that there was no involvement of Archean crust in the formation of the Early Proterozoic rocks. Most of the ages for metasedimentary rocks in the quadrangle, listed in appendix A as paragneiss, granite gneiss, and migmatite, are between 1,650 and 1,170 Ma, substantially younger than 1,700 Ma. The K-Ar ages likely reflect partial resetting during postdepositional intrusive activity and related metamorphism. This is particularly evident for the migmatites, which have K-Ar ages of 1,368–1,209 Ma but which demonstrably formed during intrusion of the 1,710-Ma Cross Creek Granite (Wallace and Blaskowski, 1989; Tweto, 1974).

Early Proterozoic intrusive activity in central Colorado occurred, along with regional metamorphism and deformation, between about 1,750 and 1,670 Ma, based upon U-Th-Pb ages on zircon suites (Reed and others, 1987). Equivalent rocks within the Leadville quadrangle include the Cross Creek Granite, Denny Creek and Kroenke Granodiorites, and possibly the granite of Holy Cross City. A six-point Rb-Sr isochron date from the Cross Creek Granite in the northern Sawatch Range and the Gore Range is 1,710 Ma (C. Hedge, unpub. data; cited in Tweto and Lovering, 1977), and a U-Th-Pb age on zircon from the Kroenke Granodiorite just south of the quadrangle is 1,669±8 Ma (Reed and others, 1987).

The Denny Creek Granodiorite is older than the Kroenke Granodiorite (Brock and Barker, 1972), and it is probably correlative with the Cross Creek Granite (E.H. DeWitt, oral commun., 1985). Two samples each of Denny Creek Granodiorite and Cross Creek Granite were used by Wetherill and Bickford (1965) for a 13-point Rb-Sr isochron that produced a 1,615-Ma age (recalculated from 1,650 Ma with new standards by J.C. Reed, Jr., unpub. data, 1987). The accuracy of this isochron, which includes rocks from a wide area in central Colorado, is difficult to determine because some samples were strongly metamorphosed after intrusion or weakly altered. The relatively less extensive granite of Holy Cross City (Tweto, 1974) is isolated from other Proterozoic intrusive rocks in the northern Sawatch Range, but, on the basis of intrusive habit and composition, Tweto (1974) tentatively assigned it to the Early Proterozoic intrusive suite. K-Ar ages for the Cross Creek Granite and the granite of Holy Cross City are unrealistically young, ranging from 1,442 to 1,184 Ma, again suggesting partial resetting by later thermal events.

The St. Kevin Granite is the most widespread Middle Proterozoic igneous rock in the Leadville quadrangle. It was emplaced during a major 1,450- to 1,429-Ma anorogenic intrusive period (Bickford, 1988) that produced largely granitic plutons and batholiths, including the Silver Plume and Sherman Granites and the informal Log Cabin granite of the Front Range, throughout Colorado. In the northern Sawatch Range, the St. Kevin Granite has a whole-rock Rb-Sr date of 1,437±70 Ma (recalculated from data in Pearson and others, 1966) and a U-Th-Pb age of 1,411±40 Ma (upper-intercept age on zircons, from data in Doe and Pearson, 1969). Other dates by various methods on individual minerals range from 1,358 Ma to as young as 1,150 Ma, indicating subsequent partial resetting.

The St. Kevin Granite variably cuts and is cut by dikes of metalamprophyre in the northern Sawatch Range (Tweto, 1974). Pearson and others (1966) obtained a K-Ar date of 1,328 Ma for one dike, but this date is probably young in light of Rb-Sr and zircon dates and of anomalously young K-Ar dates of samples of St. Kevin Granite collected nearby. Dikes of hornblendite also cut the granite (Tweto, 1974); K-Ar dates of 2,018 and 1,249 Ma do little to pinpoint the true ages of these bodies. Similarly, pegmatites are widespread throughout the Proterozoic basement, and they cut virtually all major crystalline units. Pegmatites outside of the quadrangle have dates of about 1,450 Ma, considerably older than the K-Ar dates on pegmatites of 1,343–1,368 Ma from the northern Sawatch Range.

The Hell Gate Porphyry, exposed in the upper Fryingpan River drainage (Stark and Barnes, 1932), is a coarse-grained porphyry that Tweto and Pearson (1964) considered to be a phase of the St. Kevin Granite. Limited trace-element data suggest that the Hell Gate more closely resembles the older Cross Creek Granite (A. Wallace, E. DeWitt, unpub. data, 1985); U-Th-Pb geochronology on zircons from the Hell Gate Porphyry is in progress (E. DeWitt, oral commun., 1992).

In the Mosquito Range northwest of Fairplay, the two-mica Treasurevault stock is mineralogically similar to other Middle Proterozoic intrusive rocks (Kuntz and Brock, 1977), and a K-Ar date (the material analyzed is unknown) of 1,430±45 on the stock supports a Middle Proterozoic age. However, considering the consistently young K-Ar dates for the Proterozoic rocks in the Sawatch Range to the west, confirmation of this age by U-Th-Pb dating of zircon would be useful.

PALEOZOIC AND MESOZOIC DATES

With the exception of several Late Cretaceous igneous rocks, Pennsylvanian and Permian sedimentary rocks are the only pre-Tertiary Phanerozoic rocks within the quadrangle that have been dated. Nevertheless, many Proterozoic and Tertiary rocks have produced Paleozoic and Mesozoic dates. For the Tertiary rocks, all of which are plutonic, the abnormally old K-Ar dates probably can be attributed to excess argon.

The Pennsylvanian to Permian sedimentary rocks of the Minturn, Maroon, and Gothic Formations were derived from erosion of Early to Middle Proterozoic crystalline rocks in nearby highlands, and the contained apatites and zircons are therefore of Proterozoic age. Fission-track dates on zircons from the sedimentary rocks near Gilman range from 231 Ma to "Proterozoic" (as stated in Beaty and others, 1990a), and dates on apatites range from about 33 to 39 Ma.

The principal causes of the post-Middle Proterozoic dates on clearly older rocks and minerals are partial annealing and degassing during prolonged Phanerozoic burial and partial to complete resetting during Tertiary thermal events. The effect of young thermal resetting is well documented around the 36-Ma Gilman ore deposit, where the heat from a large hydrothermal and intrusive system partially to completely annealed fission tracks in the Early Proterozoic Cross Creek Granite and the Middle Pennsylvanian Minturn Formation (Beaty and others, 1990a).

Dates that are the products of burial-related annealing cannot be documented with any certainty, in part because most samples that have been dated were collected near Tertiary hydrothermal ore deposits. The maximum thickness of Paleozoic and Mesozoic sedimentary rocks above the Proterozoic basement was about 3.4 km above the site of the Sawatch Range (Hansley, 1981) and exceeded 10 km (Wallace, 1990) in the deeper basins. With a paleothermal gradient of 31 °C/km (Nuccio and others, 1989), Proterozoic rocks at the site of the Sawatch Range (and other basement uplifts) would have resided at a temperature of about 105 °C by the end of the Mesozoic, barely sufficient over time to totally anneal fission tracks in apatite and possibly enough to cause only partial annealing in zircon (Naeser, 1976); basement rocks beneath the deeper basins would have had a temperature of at least 310 °C, sufficient to anneal tracks in both zircon and apatite. The effects on apatite and zircon in overlying units obviously would have been correspondingly smaller. Therefore, some of the anomalously young ages in pre-Tertiary rocks peripheral to mineralized areas may be due wholly or in part to Phanerozoic burial rather than to Tertiary hydrothermal events. Additional work on samples that were unaffected by Tertiary heating would provide useful information on burial histories.

LATE CRETACEOUS AND CENOZOIC DATES

Approximately three-quarters of the isotopic dates from the Leadville quadrangle are Late Cretaceous or younger; all apatite fission-track ages, including those from pre-Late Cretaceous rocks, are less than 73 Ma (fig. 3). For the most part, this high percentage reflects interest in and studies of ore deposits and related igneous rocks in the area, virtually all of which have proven to be of Tertiary age. However, in addition to dating mineral deposits, the data also provide important information regarding magmatic systems (Bookstrom, 1990; Mutschler and others, 1989) and tectonic events (Bryant and Naeser, 1980; Wallace and Naeser, 1986).

IGNEOUS SYSTEMS

Using the data in appendix A and published and unpublished crosscutting field relations, the ages of the major igneous bodies in the quadrangle can be reasonably approximated. As shown in table 1, the ages of the igneous units fall into three broad groups: (1) Laramide

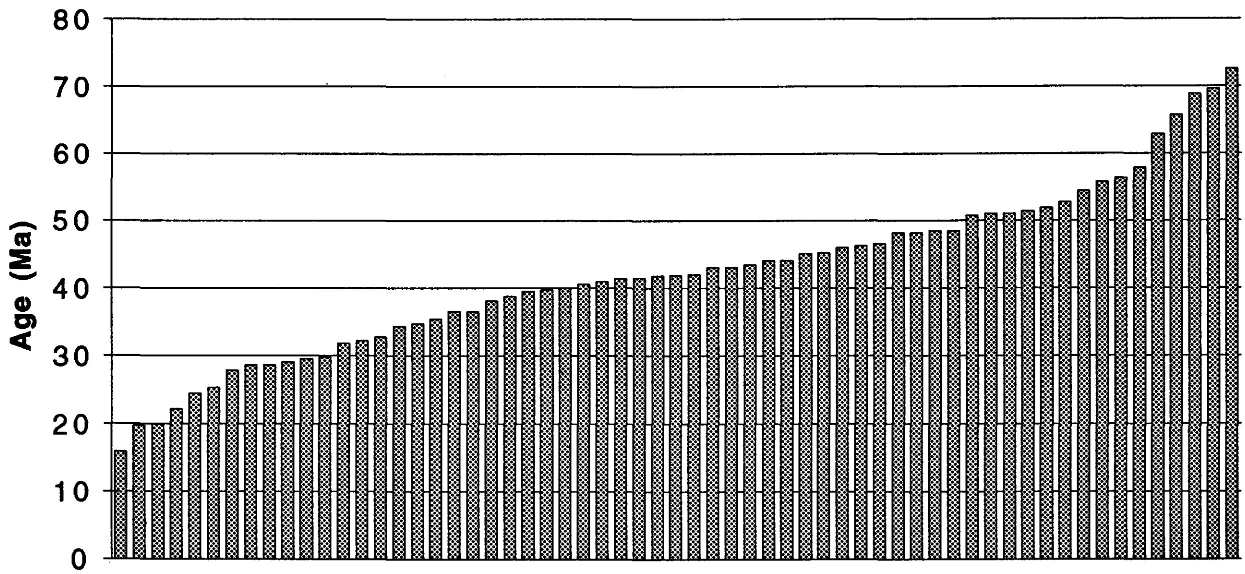


Figure 3. Cretaceous and Cenozoic apatite fission-track dates for rocks in the Leadville 1°×2° quadrangle. Each vertical bar represents a single date.

Table 1. Summary of ages of major Late Cretaceous and Tertiary igneous rock units, Leadville 1°x2° quadrangle

Unit	Age (Ma)	Comment
Grand Mesa basalt	10	
Treasure Mountain granite	13	
Flat Tops basalts	8–26	
Mount Bellview quartz monzonite	24	
Climax intrusive complex	24–33	
Buckskin Gulch (youngest system)	25–27	
Chalk Mountain stock	27.7	
Mount Sopris stock	34	
Snowmass pluton	35	
Whiterock pluton	35	
Bucksin Gulch (intermediate system)	35–44	
Pine Creek stock	36	
Timberline Lake latite	36	
Turquoise Lake stock	36	
Johnson Gulch Porphyry	42	67 Ma from Simmons and Hedge (1978).
Tucker Mountain stock	43	
Swan Mtn. quartz monzonite sill	44	
Evans Gulch Porphyry	>47	64 Ma from Simmons and Hedge (1978).
Eagle River Porphyry	>53	Date is on partially annealed zircon (Beaty and others, 1987).
Halfmoon Creek stock	>54	Date is on altered rock (Van Loenen and others, 1989).
West Cross Creek stock	62	Likely 64 Ma, based upon similarity to Twin Lakes stock.
Sacramento Porphyry	>63.8(?)	Cut by Lincoln Porphyry; may be younger (Thompson and Arehart, 1990).
Treasure Vault stock	64	
Twin Lakes stock	63.8	
East Lake Creek stock	65	
Fulford stock	65	Similar to 68-Ma Buckskin Gulch stock.
Syenodiorite	65	
Lincoln Porphyry	66	Likely 64 Ma, based upon similarity to Twin Lakes stock.
Quail Porphyry	>63.8	Older than Lincoln Porphyry.
Elk Mountain porphyry	>63.8	Older than Lincoln Porphyry.
Humbug stock	>66	
West Tennessee Creek stock	66	Similar to 68-Ma Buckskin Gulch stock.
Buckskin Gulch stock (oldest system)	56–71	
Missouri Creek stock	71	Similar to 68-Ma Buckskin Gulch stock.
Pando Porphyry	72	

(72–60 Ma), (2) middle Tertiary (44–32 Ma), and (3) late Tertiary–Quaternary (27 Ma–4,150 years). When the K-Ar dates are plotted (fig. 4), these divisions are distinct, especially the major hiatus in igneous activity between about 60 and 45 Ma. The plot also shows three possible subgroupings of the late Tertiary–Quaternary suite at 28–18 Ma, 14–8 Ma, and less than 2 Ma.

As discussed by Bookstrom (1990) and Mutschler and others (1989), the three major groupings correspond to more regional magmatic patterns. Laramide monzonites and granodiorites are products of subduction-related magmatism and compression. Subduction-related processes waned after about 45 Ma, producing monzogranites over a broad area for about 15 m.y. Rift-related magmatism and tectonics commenced at about 30 Ma and have continued into the Holocene, producing basalts and alkali-feldspar granites.

Among the Laramide plutons, the Pando Porphyry is the oldest widespread intrusive unit, although a variety of dikes of equivalent age are scattered throughout the Sawatch Range. The largest Laramide intrusive suite includes the Twin Lakes stock, the Lincoln Porphyry, and the informal West Cross Creek granite, all of which are distinguished by abundant large orthoclase phenocrysts and similar trace-element geochemistry. Due to the accuracy and precision of the dating method, the $^{40}Ar/^{39}Ar$ date of 63.8 Ma on the Twin Lakes stock is probably the true age of the other two intrusives as well, which have been dated at about 66 and 62 Ma, respectively.

A second widespread suite of Laramide plutons includes the fine-grained granodiorites of the Buckskin Gulch, Fulford, Missouri Creek, and West Tennessee Creek stocks, the latter three of which form a northwest-trending belt through the northern Sawatch Range. The Lincoln Porphyry cuts the early phases of the composite Buckskin Gulch stock (Bergendahl, 1963; Bookstrom, 1989), consistent with a range of dates on the Buckskin Gulch stock of 67–71 Ma. Dates on the Sawatch Range plutons range from 62 to 70 Ma, but cluster around 65 Ma. The northwest-trending intrusive belt in the Sawatch Range also includes several other large stocks, including the East Lake Creek stock and the intrusive

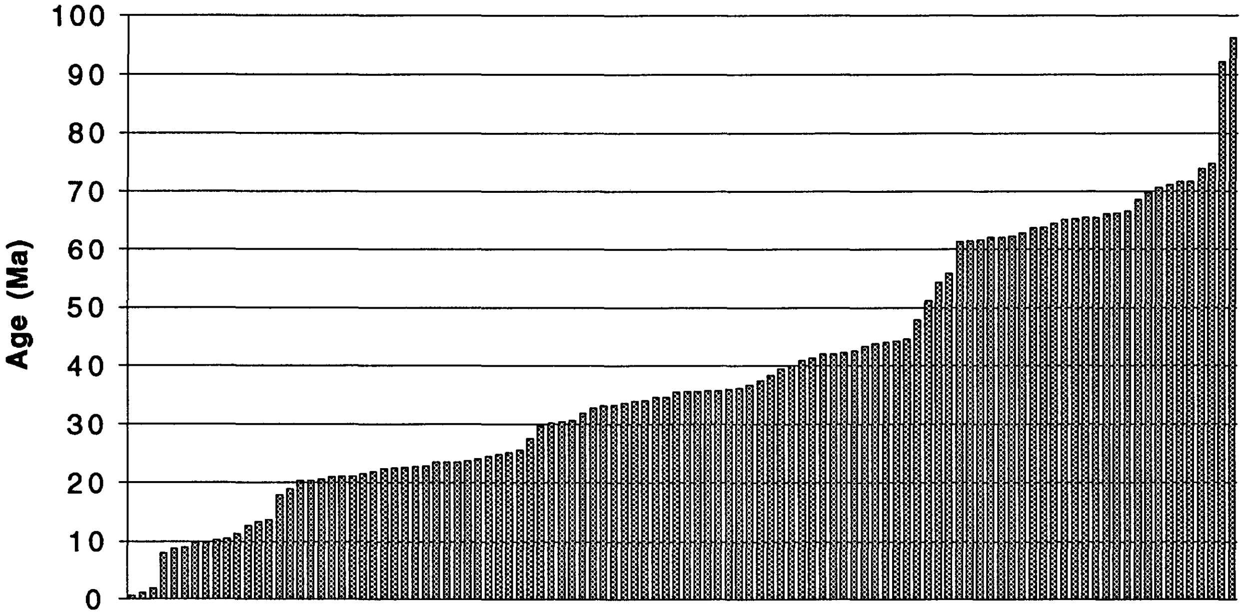


Figure 4. Potassium-argon dates for Cretaceous and Cenozoic igneous rocks in the Leadville 1°×2° quadrangle. Each vertical bar represents a single date.

complex at Treasure Vault Lake, as well as abundant dikes of various compositions; dates and crosscutting relationships indicate that all intrusive activity occurred between about 70 and 62 Ma (Wallace and others, 1986; Wallace and Blaskowski, 1989). Pearson and others (1962) and Tweto (1974) suggested that the 72-Ma Pando Porphyry was the shallow equivalent of the granodiorites. However, the large Fulford stock was emplaced into sedimentary rocks as young as Cretaceous (Tweto and others, 1978; Wallace and others, 1989), considerably higher in the section than the older (by at least 5 Ma) Pando, which occurs near the contact between the Pennsylvanian Minturn and Belden Formations.

As described by Bookstrom (1990), relatively more mafic monzongranitic and granodioritic Laramide magmatism gave way to more felsic and potassic middle Tertiary monzongranitic plutonism. Within the quadrangle, the middle Tertiary intrusives were emplaced between about 44 and 33 Ma. Large stocks and laccoliths of the Elk Mountains, including the White Rock and Snowmass plutons and the Mount Sopris stock, were emplaced at about 34–35 Ma. The Grizzly Peak cauldron, one of several calderas along the subdued (Shannon and others, 1987) crest of the southern Sawatch Range, formed at roughly the same time (33 Ma). In the eastern part of the quadrangle, a variety of plutons were emplaced in the Breckenridge, Kokomo, Alma, and Leadville mining districts between about 44 and 39 Ma.

Late Cenozoic igneous rocks are the products of bimodal rift-related magmatism. The principal products of this activity are alkali-feldspar granites at Climax (24–33 Ma) and Treasure Mountain dome (13 Ma), and extensive basalt flows in the Flat Tops and Aspen areas. The basaltic activity in the quadrangle commenced at about 26 Ma and continued essentially to the present, with the youngest flow having an age of only 4,150 years. Minor rhyolite flows and breccia pipes in the Flat Tops have not been dated but are believed (Tweto and others, 1978) to be the felsic phase of the bimodal volcanism.

Various reports provide conflicting ages for several intrusive suites. The Sacramento Porphyry, which occurs as dikes and sills in the Tennessee Pass and Leadville districts, is cut by the 66-Ma Lincoln Porphyry (Tweto, 1974). At Tennessee Pass, Beaty and others (1987) interpreted a zircon fission-track date of 53.6 Ma to be the result of postcrystallization thermal resetting related to gold mineralization. In contrast, Thompson and Arehart (1990) considered a zircon fission-track date of 43.9 Ma from the Sacramento Porphyry in Leadville to be the age of crystallization rather than a product of thermal resetting, and they suggested that the dated unit at Tennessee Pass might not be Sacramento Porphyry. In light of the crosscutting field relations (Tweto, 1974), it seems more likely that the Leadville date is not the age of intrusion but instead reflects thermal resetting during district-wide mineralization, as is the case at Tennessee Pass. However, Tweto (1960) noted that 25–30 varieties of intrusive rocks are exposed in the Leadville district, 15 of which are distinct enough to be differentiated into an intrusive sequence, so it is possible that intrusives of different ages have been erroneously called the same unit.

Similarly, the Johnson Gulch Porphyry has been dated at 67 Ma (Simmons and Hedge, 1978), 43.1 Ma (Thompson and Arehart, 1990), and 42.1 Ma (Pearson and others, 1962). Crosscutting relationships with other intrusives are equivocal, but Tweto (1974) felt, on the basis of admittedly limited field relations, that the Johnson Gulch was a

Laramide intrusive. The unit clearly is older than the 39.6-Ma ore bodies of the Leadville district (Thompson and Arehart, 1990). The 43.1-Ma date is a fission-track determination on zircon from a sample collected less than 2 km from the thermal center of the district, but Thompson and Arehart (1990) interpreted the date to be the age of crystallization rather than a product of thermal resetting. Considering that the Johnson Gulch Porphyry was an important ore control in the district, additional geochronology is warranted for this intrusive unit.

MINERAL DEPOSITS

Hydrothermal mineral deposits were formed during the three major periods of intrusive activity described in the previous section. Bookstrom (1989, 1990) and Bookstrom and others (1987) have provided detailed summaries regarding the relationship between igneous rocks and mineral deposits in central Colorado, and the reader should refer to those publications for a complete synthesis. On the basis of field relations, many of the deposits originally were thought to be of Laramide age, but detailed geochronologic studies have shown that, in addition to Laramide ore formation, mineral deposits formed throughout the Tertiary. A summary of the known and inferred ages of mineral deposits in the quadrangle is given in table 2, and the locations of the mining districts are shown in figure 5.

Several methods were used to determine the ages of the mineral deposits in the quadrangle. The ages of some deposits, such as Leadville, Gilman, Climax, and Turquoise Lake, could be determined directly by dating hydrothermal minerals such as sericite or apatite. Many deposits do not have minerals suitable for dating, so indirect methods were employed. In some cases, such as at Aspen and along the northwest-trending belt of intrusive rocks in the northern Sawatch Range, the age of mineralization could be bracketed between the ages of pre- and post-ore intrusive rocks (Bryant and others, 1990; Wallace and others, 1989). The ages of other deposits, such as at Holy Cross City, can be inferred, correctly or not, from the age of spatially associated intrusive rocks. The age of Sherman-type carbonate-hosted ore deposits in the Leadville and other districts (Behre, 1953) is still under contention for lack of unequivocal crosscutting relationships with dateable intrusive rocks. Landis and

Table 2. Summary of ages of ore deposits, Leadville 1°x2° quadrangle

Mining district	Age (Ma)	Reference to age	Comment
Alma	27	Bookstrom (1989)	Ore-forming events occurred between 35 and 27 Ma.
Ashcroft	Laramide	Bryant (1979)	Likely related to mineralizing event at Aspen district.
Aspen	55–70	Bryant and others (1990)	Can only be constrained to be Laramide.
Breckenridge	39.3–41.4	Pride and Robinson (1978)	Related to intrusive complex of similar age.
Brush Creek	Undated	Gabelman (1951)	Hosted by Mesozoic sedimentary rocks.
Buckskin	27.6	Bookstrom and others (1987)	Related to intrusive complex of similar age.
Climax	27–29	White and others (1981)	Multiple intrusive and mineralizing events.
Frisco	Undated	Bergendahl (1963)	Veins in Proterozoic rocks.
Fulford	Undated	A. Wallace, unpub. data	Likely Laramide based on associated intrusives.
Gilman	35.2	Beaty and others (1990a)	Related to concealed intrusive center east of district.
Granite	65.3(?)	Hedlund and others (1985)	Dated dikes intimately associated with veins.
Green Mountain	29.9	Naeser and others (1973)	Likely related to nearby intrusive complex.
Holy Cross City	Undated	Tweto (1974)	Likely Laramide based on associated intrusives.
Homestake	Undated	Tweto (1974)	Associated with stratabound Proterozoic sulfides.
Independence	Undated	Fridrich and others (1991)	Controlled by 34-Ma Grizzly Peak cauldron ring fracture.
Kokomo	40	Mach (1992)	Replacement and vein deposits.
Leadville	39.6	Johansing and Thompson (1990)	Replacement and vein deposits.
Lenado	Laramide	Bryant (1979)	Replacement deposits related to Aspen district.
Lincoln Gulch	34.8(?)	Fridrich and others (1991)	Likely related to 34.8-Ma Lincoln Gulch stock.
Marble	12.8	Mutschler (1980)	Related to Treasure Mountain granite.
Richmond Hill	Laramide	Bryant (1979)	Likely related to Aspen district mineralizing event.
Rifle Creek Vanadium	Undated	Fischer (1960)	Hosted by Mesozoic sedimentary rocks.
Snowmass	34	Obradovich and others (1969)	Based on association with Snowmass pluton.
St. Kevin/Sugarloaf	35.6	Craig (1980)	Peripheral veins related to intrusive event of same age.
Tenmile	Undated	Bergendahl and Koschmann (1971)	Similar to mid-Tertiary Kokomo district.
Tennessee Pass	38–42	Beaty and others (1987)	Related to possible intrusive event of same age.
Timberline Lake	35.9	Tweto (1974)	Related to intrusive complex of same age.
Turquoise Lake	35.6	Craig (1980)	Related to intrusive complex of same age.
Upper Blue River	Undated		May be same age as Breckenridge district.
West Cross Creek	61 and 30(?)	Wallace and Blaskowski (1989)	61-Ma veins and middle Tertiary(?) stockwork Mo.
Weston Pass	Undated		Sherman type: may be Paleozoic or Tertiary.
Yarmony	Undated	Donner (1949)	Stratiform Cu-Pb in Cambrian sandstone.

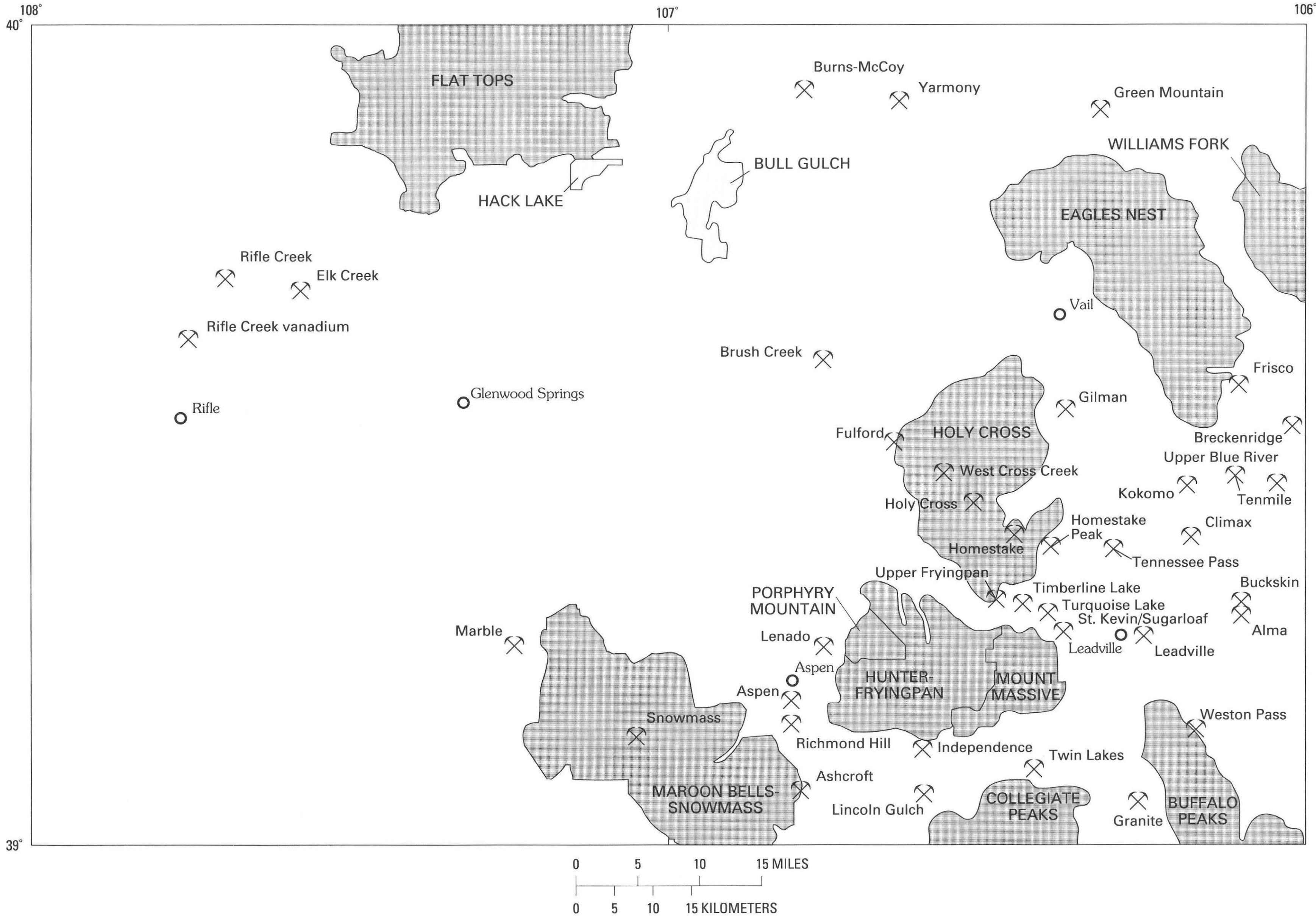


Figure 5. Locations of major mining districts and mineral deposits in the Leadville 1°×2° quadrangle. Towns, U.S. Forest Service wilderness areas (shaded dark gray), and U.S. Bureau of Land Management wilderness study areas (shaded light gray) are shown for reference.

Tschauder (1990) believed them to be Late Mississippian, whereas Johansing and Thompson (1990) argued for an early to middle Tertiary age (also see discussion and reply by G. Landis and R. Johansing in Beaty and others, 1990b).

At the Gilman, Tennessee Pass, and Kokomo districts, fission tracks in apatite and zircon were totally to partially annealed by the ore-forming thermal event, and dates on those minerals established the age of mineralization reasonably well. Similar methods were employed with less success at Leadville and Aspen. Apatites in closest proximity to the ore bodies were totally annealed by the thermal event, and fission-track dates reflect the time since the end of that event. The amount of annealing decreases away from the thermal center, and fission-track dates are correspondingly older. Zircons, which are more resistant to thermal annealing (Naeser, 1976), are proportionately less annealed but tend to have dates that are progressively younger towards the thermal center. As a result, these dates, when plotted, show a decrease towards the actual age of mineralization (fig. 6). At Gilman, decreasing zircon and apatite dates (fig. 6*A*, *B*) indicate a thermal event between about 30 and 40 Ma, consistent with a 35.8-Ma date on hydrothermal apatite (Beaty and others, 1990a). At Tennessee Pass, similar annealing trends (fig. 6*C*, *D*) suggest a thermal event between about 35 and 40 Ma (Beaty and others, 1987), but the mineralizing event has not been dated directly. At Aspen, general geologic relations and dated rocks bracket the age of mineralization between about 70 and 55 Ma (Bryant and others, 1990), and fission-track dates from apatite (fig. 6*E*) and zircon (fig. 6*F*) do little to further constrain those dates. At Leadville, all apatite was destroyed during the 39.6-Ma mineralizing event, and all but three zircon fission-track dates are younger (by as much as 5–10 Ma) than the age of mineralization (fig. 6*G*), which is known from K-Ar ages on hydrothermal sericite. Considering the relative resistivity of zircon to annealing, the young ages indicate that the zircons remained hot until well after mineralization. Thompson and Arehart (1990) suggested that the young ages indicated progressive cooling of the thermal system over a "5- to 6-m.y. period." Alternatively, the young ages could reflect uplift-related cooling (discussed in subsequent section) or a younger unidentified intrusive event.

TECTONIC EVENTS

Dates on various igneous rocks constrain the ages of Late Cretaceous and Tertiary faults and structures. Along the west flank of the Sawatch Range near Aspen, the range-bounding Castle Creek fault zone cuts 74-Ma quartz porphyry dikes and the early Laramide Elk Range thrust fault, and a 69-Ma aplite dike was emplaced along the fault (Bryant, 1979; Obradovich and others, 1969). Therefore, Laramide uplift near Aspen took place between 74 and 69 Ma. At the northwest end of the range, range-bounding faults cut sills of the 65-Ma Fulford stock (Wallace and others, 1986), indicating that uplift-related fault movement continued until after at least 65 Ma. At Leadville, Tweto (1960) determined the sequence of intrusion of various porphyries, and he used that sequence to document the sequential development of the pre-ore fault systems in the district. As most of the intrusives are Laramide, based upon subsequent dating, much of the faulting was therefore Laramide as well, although many were reactivated after mineralization at 39.6 Ma.

Apatite can be used to date these events (Naeser, 1976), and several studies (Bryant and Naeser, 1980; Wallace and Naeser, 1986; Shannon and others, 1987) have focused on uplift and the Cenozoic thermal history of the Sawatch Range. In unmineralized areas of the northern Sawatch Range, apatite dates are scattered but tend to fall into two groups: 56–51 Ma at generally higher elevations, and 46–43 Ma at generally lower elevations around the margins of the Sawatch uplift (Wallace and Naeser, 1986; Shannon and others, 1987; Bryant and Naeser, 1980; Beaty and others, 1990a). Zircon and sphene fission-track dates from the Twin Lakes stock are 42 and 46 Ma, respectively (Shannon, 1988). These dates fall into a period of magmatic and hydrothermal quiescence in the northern Sawatch Range (note the relative paucity of K-Ar dates in the 60- to 45-Ma interval, fig. 3), and they may reflect Eocene uplift that is not recorded elsewhere in the geologic record. Alternatively, the Eocene dates might reflect residence in a depth-temperature zone of partial annealing, followed by a post-42-Ma uplift event (Shannon, 1988). Regardless, the Proterozoic core of the range was exposed at the time of formation of the 34-Ma Grizzly Peak cauldron, into which Proterozoic wall rocks slumped during caldera collapse (Fridrich and others, 1991).

Across the central Sawatch Range, fission-track dates on apatite are progressively younger to the east with increased proximity to the Arkansas River valley. The youngest dates, as young as 15 Ma, come from the narrow elongate horst that includes the 14,000-ft peaks of the Collegiate Peaks and that extends north to include Mt. Elbert and Mt. Massive (Bryant and Naeser, 1980; Shannon and others, 1987; Shannon, 1988). Bryant and Naeser (1980) suggested that the ages reflected westward tilting of the Sawatch Range, with deeply buried apatites having been exposed and cooled relatively later along the east margin of the range. Shannon's (1988) fission-track and field data indicate instead a step-like, up-to-the-east series of northerly trending blocks across the range, culminating to the east in the Collegiate horst, which is adjacent to the major down-dropped Arkansas River valley graben, part of the Rio Grande rift system. The progressively younger ages to the east imply significant and rapid uplift of the blocks, especially the Collegiate horst, relative to the graben.

To the east of the Arkansas River valley graben, the Mosquito Range does not have a physiographic equivalent to the Collegiate horst, nor has a similar fission-track traverse been attempted. However, geologic relations indicate that the Leadville ore deposits, which formed at a depth of several kilometers (Thompson and Beaty, 1990), had been exhumed and partially oxidized before the Miocene and Pliocene deposition of the basin-filling Dry Union Formation. The young (relative to the 39.6-Ma age of mineralization) zircon dates in the Leadville district, discussed previously, may reflect the uplift that led to the exposure of the ore bodies.

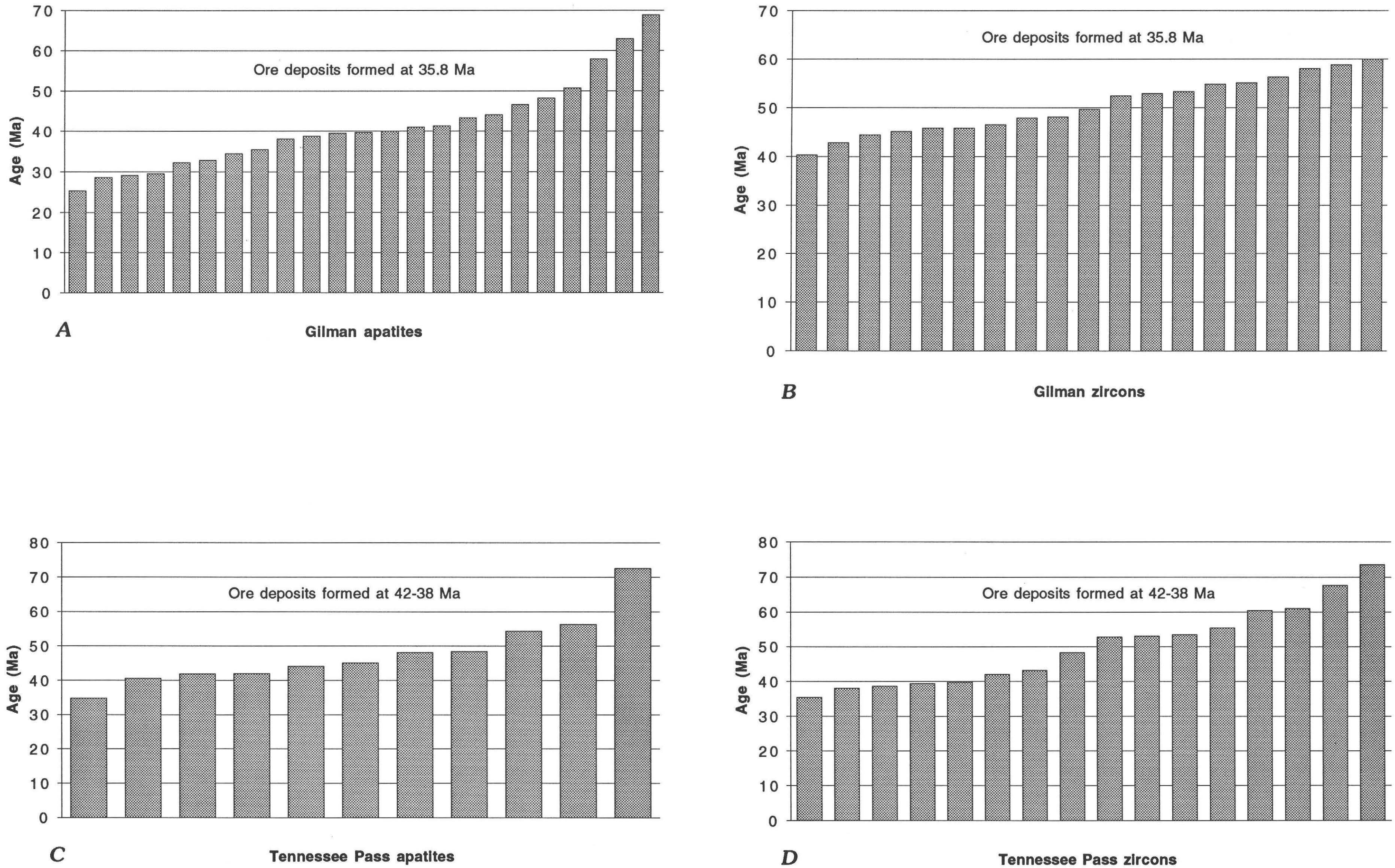
Larson and others (1975) used K-Ar dates on Tertiary basalt flows to demonstrate the timing of Neogene tectonic activity and the development of the Colorado River system. Prior to about 10 Ma, tectonic activity was minimal and the topography was subdued. At about 10 Ma, tectonic activity increased, reactivating Laramide uplifts and producing related folds and faults that deformed existing basalt flows. Streams and rivers began incising new valleys into which post-10-Ma flows were erupted at progressively lower elevations. The youngest basalts are about 4,150 years old; they were erupted on the north flank of the Eagle River valley and flowed to the floor of the valley near its modern confluence with the Colorado River.

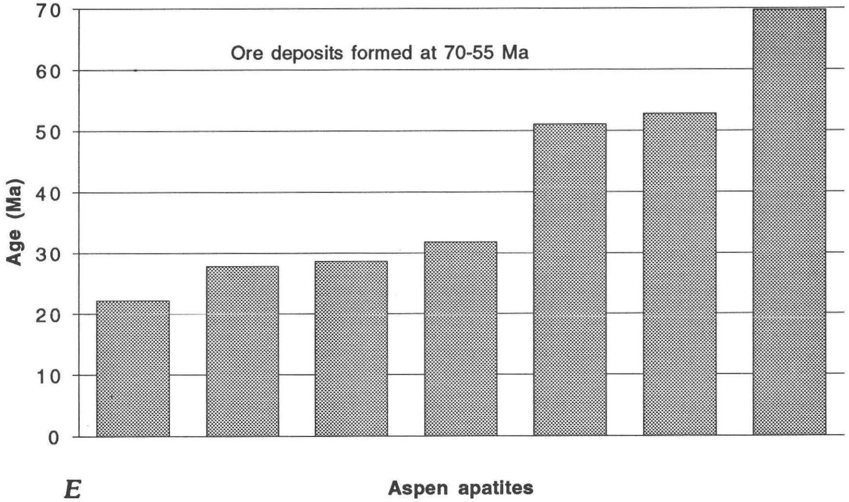
Basalt flows cap Grand and Battlement Mesas in the southwestern part of the quadrangle, and the major flow along the southwest margin of the quadrangle was dated at 10 Ma (U.S. Geological Survey, 1966). Roughly east- to east-northeast-trending basalt dikes cut Paleogene sedimentary rocks to the east of the flow, and Yeend (1969) inferred that they were related to the flows. If so, the consistent trend of the dikes implies a north to north-northwest direction of least compressional stress in the middle Miocene. Verbeek and Grout (1986) showed a progressive counterclockwise orientation, from north-northwest to north-northeast, of extensional fracturing in the Piceance Basin between the late Eocene and late Miocene. The dikes correspond in orientation to the intermediate but undated F_2 and F_3 stages (Verbeek and Grout, 1986) of fracturing, both of which occurred before the F_4 stage produced during the renewed tectonic activity at about 10 Ma (M.A. Grout, oral commun., 1983). Additional geochronology is needed to constrain dike formation within the rotating regional stress regime documented by Verbeek and Grout (1986).

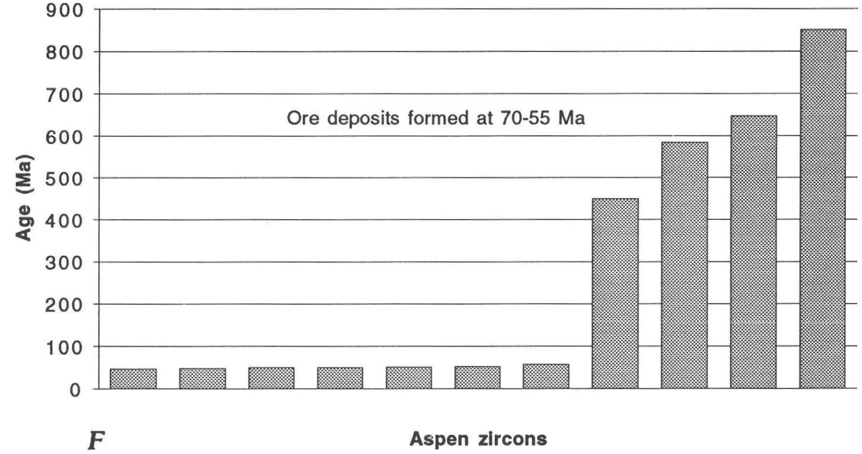
UNDATED UNITS AND EVENTS

Several important igneous units in the quadrangle either have not been dated or have inadequate dates. In addition, further data are needed on the uplift of major horsts such as the Gore and Mosquito Ranges. Possible additional studies are briefly described as follows:

- Considering the amount of Proterozoic igneous rocks that are exposed in the quadrangle, the amount of geochronologic data is trivial. U-Th-Pb dates on zircons from the St. Kevin and Cross Creek Granites and the Denny Creek and Kroenke Granodiorites, and related intrusive rocks in the White River uplift, Gore Range, and Front Range would substantially refine the understanding of the Proterozoic history of this area.
- A major intrusive body at the north edge of the quadrangle cuts Proterozoic gneisses and Paleozoic sedimentary rocks. Donner (1949) described it as a monzonite porphyry, and Tweto and others (1978) included it in the middle Tertiary category of intrusive rocks, although the rationale behind this classification is unclear. Copper-lead deposits occur in Paleozoic sandstones adjacent to the stock, although the genetic relation is unknown.
- Rhyolite dikes fill north-trending faults that extend north from Turquoise Lake (Tweto, 1974). These faults are related to formation of the Rio Grande rift, and dates on these dikes would provide important information regarding the timing and style of rifting at this latitude. Also, as little igneous activity is directly related to the rift at this latitude, a date, coupled with more detailed geochemical studies, would fill a void in the petrochemical history of rift-related igneous activity.
- Small rhyolite flows are exposed along the east side of the Flat Tops in the Colorado River valley. Tweto and others (1978) designated them as rhyolites related to Neogene bimodal volcanism, of which the extensively dated basalt flows (Larson and others, 1975) are the mafic component. Considering that the mafic volcanism spanned 26 m.y., knowledge of the age(s) of felsic volcanism would provide information necessary for petrogenetic modeling of bimodal volcanism.
- A small middle Tertiary (Tweto and others, 1978) intrusive body cuts Paleogene sedimentary rocks in the western part of the quadrangle (approximately lat 39°17′ N., long 107°28′ W.). The stock was emplaced along the southeastward projection of an anticline, and the age of intrusion could place a minimum age on the time of deformation.
- Despite all the dates that have been obtained from the Johnson Gulch Porphyry in the Leadville district, the absolute age of intrusion is still equivocal. Was the Johnson Gulch emplaced shortly before mineralization at Leadville, as proposed by Thompson and Arehart (1990), or was it a Laramide intrusive unit, as postulated by Tweto (1974) and dated by Simmons and Hedge (1978)? Additional geochronology and petrology are warranted to resolve the problem.
- Unlike the Sawatch Range, virtually no data exist on the timing of uplift of the Gore and Mosquito Ranges. Fission-track traverses across both ranges could provide important information on both the timing and styles of uplift; a study on the Gore Range north of Vail Pass is currently (1994) underway (C.W. Naeser, oral commun., 1994). Similar studies could be applied to the White River uplift, especially in conjunction with the geochronology on the basalt flows (Larson and others, 1975).


Ore deposits formed at 35.8 Ma
Age (Ma)
A
Gilman apatites
Ore deposits formed at 35.8 Ma
Age (Ma)
B
Gilman zircons
Ore deposits formed at 42-38 Ma
Age (Ma)
C
Tennessee Pass apatites
Ore deposits formed at 42-38 Ma
Age (Ma)
D
Tennessee Pass zircons





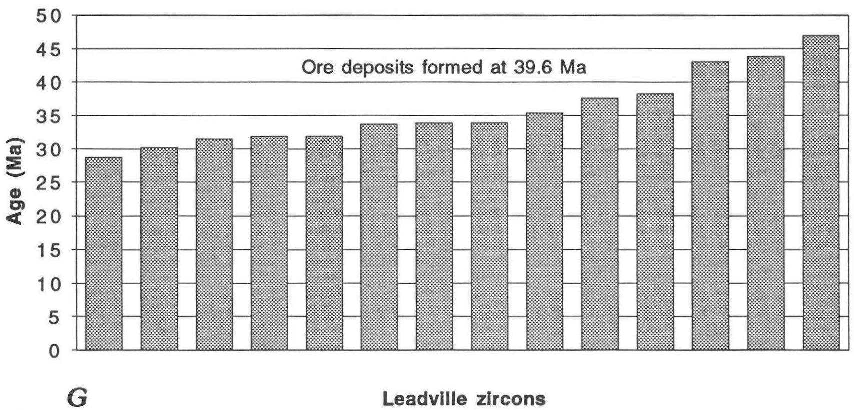


Figure 6. Apatite and zircon fission-track data for the Gilman (*A*, *B*), Tennessee Pass (*C*, *D*), Aspen (*E*, *F*), and Leadville (*G*) mining districts in the Leadville 1°×2° quadrangle. Each vertical bar represents a single date. With the exception of Tennessee Pass, the ages of mineralization are based upon other geologic and geochronologic evidence. All apatite in host rocks in the Leadville district was destroyed by hydrothermal alteration.

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APPENDIXES

Appendix A. Summary of isotopic geochronology and related information, Leadville 1°x2° quadrangle, Colorado

[Method: C-14, carbon-14; FT, fission track; K-Ar, potassium-argon; Nd-Sm, neodymium-samarium; Pb-alpha, lead-alpha; Rb-Sr, rubidium-strontium; U-Th-Pb, uranium-thorium-lead]

Map No.	Unit name	Sample No.	Latitude (N.)	Longitude (W.)	County	7-1/2-minute quadrangle	Method	Mineral
1	Rhyolite ash fall	65G57	40 02 00	106 17 55	Grand	Junction Butte	FT	Zircon
2	Basalt	—	39 59 37	107 12 04	Garfield	Trappers Lake	K-Ar	Whole rock
3	Basaltic andesite	—	39 57 52	107 07 52	Garfield	Trappers Lake	K-Ar	Whole rock
4	Basalt	—	39 57 00	106 32 00	Grand	Radium	K-Ar	Whole rock
5	Basalt, nepheline-normative.	—	39 56 55	106 43 18	Routt	McCoy	K-Ar	Whole rock
6	Basaltic andesite	—	39 56 40	107 15 00	Garfield	Trappers Lake	K-Ar	Whole rock
7	Basalt	—	39 55 45	107 00 00	Routt	Gypsum	K-Ar	Whole rock
8	Basalt	1-5-2	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
9	Basalt	1-5-1	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
10	Basalt	1-8-1	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
11	Basalt	1-6-1	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
12	Basalt	1-3-1	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
13	Basalt	1-4-1	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
14	Basalt	1-7-1	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
15	Basalt	10A	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
16	Basalt	8A	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
17	Basalt	16A	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
18	Basalt	4A	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
19	Basalt	16A	39 54 30	106 38 30	Eagle	McCoy	K-Ar	Whole rock
20	Basaltic andesite	—	39 52 43	107 10 32	Garfield	Trappers Lake	K-Ar	Whole rock
21	Basaltic andesite	—	39 52 43	107 10 32	Garfield	Trappers Lake	K-Ar	Whole rock
22	Latite porphyry	72N2	39 52 43	106 19 17	Summit	King Creek	FT	Zircon
23	Green Mountain trachyte dike.	—	39 52 00	106 19 30	Summit	Mount Powell	FT	Zircon
24	Basalt	—	39 50 48	107 11 13	Garfield	Sweetwater Lake	K-Ar	Whole rock
25	Basalt	—	39 50 48	107 11 13	Garfield	Sweetwater Lake	K-Ar	Whole rock
26	Basalt	—	39 50 48	107 11 13	Garfield	Sweetwater Lake	K-Ar	Whole rock
27	Basalt	—	39 50 48	107 11 13	Garfield	Sweetwater Lake	K-Ar	Whole rock
28	Basalt	—	39 50 48	107 11 13	Garfield	Sweetwater Lake	K-Ar	Whole rock
29	Basalt	—	39 50 48	107 11 13	Garfield	Sweetwater Lake	K-Ar	Whole rock
30	Basalt	—	39 50 48	107 11 13	Garfield	Sweetwater Lake	K-Ar	Whole rock
31	Felsic gneiss/ amphibolite.	—	39 48 00	106 22 00	Summit	Mount Powell	Nd-Sm	Whole rock
32	Basalt–Dotsero	—	39 38 47	107 02 58	Eagle	Dotsero	C-14	Wood
33	Swan Mtn. quartz monzonite sill.	USGS(D)75CS86	39 35 28	106 02 20	Summit	Frisco	K-Ar	Biotite
34	Swan Mtn. quartz monzonite sill.	75CS86	39 35 28	106 02 20	Summit	Frisco	Rb-Sr	Whole rock
35	Minturn Formation	Gil 25	39 33 22	106 23 47	Eagle	Minturn	FT	Zircon
36	Pando Porphyry	Gil 16	39 32 55	106 24 00	Eagle	Minturn	FT	Zircon
37	Pando Porphyry	Gil 42	39 32 48	106 22 48	Eagle	Minturn	FT	Zircon
38	Pando Porphyry	Gil 41	39 32 48	106 22 48	Eagle	Minturn	FT	Zircon
39	Pando Porphyry	Gil 3	39 32 45	106 23 52	Eagle	Minturn	FT	Zircon
40	Pando Porphyry	Gil 3	39 32 45	106 23 52	Eagle	Minturn	FT	Apatite
41	Cross Creek Granite	C-5	39 32 34	106 25 30	Eagle	Minturn	Pb-alpha	Zircon
42	Cross Creek Granite	C-5	39 32 34	106 25 30	Eagle	Minturn	K-Ar	Biotite
43	Cross Creek Granite	C-4	39 32 34	106 25 15	Eagle	Minturn	Pb-alpha	Zircon
44	Cross Creek Granite	C-4	39 32 34	106 25 15	Eagle	Minturn	K-Ar	Biotite
45	Pando Porphyry	Gil 48	39 32 32	106 22 33	Eagle	Minturn	FT	Zircon
46	Pando Porphyry	Gil 49	39 32 32	106 22 33	Eagle	Minturn	FT	Zircon
47	Pando Porphyry	Gil 43	39 32 28	106 22 20	Eagle	Red Cliff	FT	Zircon
48	Pando Porphyry	Gil 44	39 32 28	106 22 20	Eagle	Red Cliff	FT	Zircon
49	Cross Creek Granite	Gil 15	39 32 20	106 24 03	Eagle	Minturn	FT	Apatite
50	Cross Creek Granite	Gil 15	39 32 20	106 24 03	Eagle	Minturn	FT	Zircon
51	Pando Porphyry	Gil 40	39 32 20	106 23 24	Eagle	Minturn	FT	Zircon
52	Pando Porphyry	Gil 2	39 32 10	106 23 48	Eagle	Minturn	FT	Apatite
53	Pando Porphyry	Gil 2	39 32 10	106 23 48	Eagle	Minturn	FT	Zircon
54	Pando Porphyry	Gil 46	39 32 09	106 21 55	Eagle	Red Cliff	FT	Zircon
55	Pando Porphyry	Gil 45	39 32 05	106 21 50	Eagle	Red Cliff	FT	Zircon
56	Hydrothermal apatite	Gil 1	39 32 02	106 23 02	Eagle	Minturn	FT	Apatite
57	Cross Creek Granite	Gil 5	39 32 02	106 22 47	Eagle	Minturn	FT	Apatite
58	Cross Creek Granite	Gil 5	39 32 02	106 22 47	Eagle	Minturn	FT	Zircon
59	Basalt	—	39 32 00	107 15 20	Garfield	Glenwood Springs	K-Ar	Whole rock
60	Cross Creek Granite	Gil 7	39 31 58	106 22 52	Eagle	Minturn	FT	Apatite
61	Cross Creek Granite	Gil 7	39 31 58	106 22 52	Eagle	Minturn	FT	Zircon
62	Pando Porphyry	Gil 50	39 31 58	106 22 44	Eagle	Minturn	FT	Zircon
63	Cross Creek Granite	87N6	39 31 57	106 23 28	Eagle	Minturn	FT	Apatite
64	Minturn Formation	Gil 21	39 31 55	106 22 48	Eagle	Minturn	FT	Apatite
65	Minturn Formation	Gil 21	39 31 55	106 22 48	Eagle	Minturn	FT	Zircon
66	Minturn Formation	Gil 24	39 31 54	106 23 32	Eagle	Minturn	FT	Apatite

Age (Ma)	Analytical uncertainty	Source of date	Geologic reference	Mining district	Comment
12.8	2.3	Izett and Barclay (1973)	Izett and Barclay (1973)		Outside of quad, but unit extends into quadrangle.
23.6	1	Larson and others (1975)	Tweto and others (1978)		Recalculated.
10.6	0.5	Larson and others (1975)	Tweto and others (1978)		Recalculated.
23.8	1	Larson and others (1975)	Tweto and others (1978)		Recalculated.
0.66	0.2	Larson and others (1975)	Tweto and others (1978)		Recalculated.
13.8	0.5	Larson and others (1975)	Tweto and others (1978)		Recalculated.
22.7	1	Larson and others (1975)	Tweto and others (1978)		Recalculated; published latitude incorrect: in Gypsum quadrangle.
18		York and others (1971)	Tweto and others (1978)		Recalculated.
20.4		York and others (1971)	Tweto and others (1978)		Recalculated.
21.1		York and others (1971)	Tweto and others (1978)		Recalculated.
21.6		York and others (1971)	Tweto and others (1978)		Recalculated.
22.5		York and others (1971)	Tweto and others (1978)		Recalculated.
22.6		York and others (1971)	Tweto and others (1978)		Recalculated.
22.9		York and others (1971)	Tweto and others (1978)		Recalculated.
23.6		York and others (1971)	Tweto and others (1978)		Recalculated.
23.6		York and others (1971)	Tweto and others (1978)		Recalculated.
24.6		York and others (1971)	Tweto and others (1978)		Recalculated.
24.9		York and others (1971)	Tweto and others (1978)		Recalculated.
25.7		York and others (1971)	Tweto and others (1978)		Recalculated.
9.9	0.5	Larson and others (1975)	Tweto and others (1978)		Recalculated.
13.5	0.5	Larson and others (1975)	Tweto and others (1978)		Recalculated.
29.9	2.4	Marvin and others (1974)	Naeser and others (1973)		
29.9	2.4	Naeser and others (1973)	Tweto and others (1978)		Part of Green Mountain intrusive center.
19	0.8	Larson and others (1975)	Tweto and others (1978)		Recalculated.
20.4	0.8	Larson and others (1975)	Tweto and others (1978)		Recalculated.
20.6	0.8	Larson and others (1975)	Tweto and others (1978)		Recalculated.
21.2	0.8	Larson and others (1975)	Tweto and others (1978)		Recalculated.
21.2	1	Larson and others (1975)	Tweto and others (1978)		Recalculated.
22	1	Larson and others (1975)	Tweto and others (1978)		Recalculated.
22.8	1	Larson and others (1975)	Tweto and others (1978)		Recalculated.
1,800	90	DePaolo (1981)	Tweto and others (1978)		Date from isochron based upon several Colorado samples.
4,150 yr	300 yr	Giegengack (1962)	Tweto and others (1978)		
44.1	1.6	Marvin and others (1989)	Tweto and others (1978)	Breckenridge	
44		Simmons and Hedge (1978)	Tweto and others (1978)	Breckenridge	
231	31	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
54.9	6.2	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
58.1	6.8	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
48	5.6	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
45.2	5.1	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
63	40	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
1,300	16	Pearson and others (1966)	Tweto and Lovering (1977)		
1,442	72	Pearson and others (1966)	Tweto and Lovering (1977)		Recalculated.
1,065	20	Pearson and others (1966)	Tweto and Lovering (1977)		
1,343	67	Pearson and others (1966)	Tweto and Lovering (1977)		Recalculated.
42.9	4.8	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
56.4	8.4	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
44.5	5.2	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
49.7	5.6	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
35.5	15	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
Proterozoic		Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
53.4	6	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
28.7	22	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
45.9	4.3	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
45.9	5.8	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
48.2	7	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
34.5	4.4	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
38.2	10	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
486	64	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
10.4	0.5	Larson and others (1975)	Tweto and others (1978)		Recalculated.
29.2	18	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
671	170	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
40.4	4.6	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
32.3	4.9	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
38.9	15	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
542	95	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
213	32	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	

Appendix A. Summary of isotopic geochronology and related information, Leadville 1°x2° quadrangle, Colorado—Continued

Map No.	Unit name	Sample No.	Latitude (N.)	Longitude (W.)	County	7-1/2-minute quadrangle	Method	Mineral
67	Minturn Formation	Gil 24	39 31 54	106 23 32	Eagle	Minturn	FT	Zircon
68	Cross Creek Granite	Gil 6	39 31 54	106 22 54	Eagle	Minturn	FT	Apatite
69	Cross Creek Granite	Gil 6	39 31 54	106 22 54	Eagle	Minturn	FT	Zircon
70	Basalt	—	39 31 52	107 03 01	Eagle	Cottonwood Pass	K-Ar	Whole rock
71	Cross Creek Granite	Gil 14	39 31 52	106 24 00	Eagle	Minturn	FT	Apatite
72	Cross Creek Granite	Gil 14	39 31 52	106 24 00	Eagle	Minturn	FT	Zircon
73	Minturn Formation	Gil 23	39 31 52	106 23 12	Eagle	Minturn	FT	Apatite
74	Minturn Formation	Gil 23	39 31 52	106 23 12	Eagle	Minturn	FT	Zircon
75	Minturn Formation	Gil 22	39 31 52	106 23 05	Eagle	Minturn	FT	Zircon
76	Cross Creek Granite	87N1	39 31 52	106 22 56	Eagle	Minturn	FT	Apatite
77	Fulford stock	W3125	39 31 50	106 37 00	Eagle	Grouse Mountain	FT	Apatite
78	Cross Creek Granite	87N2	39 31 50	106 22 57	Eagle	Minturn	FT	Apatite
79	Cross Creek Granite	87N3	39 31 50	106 22 49	Eagle	Minturn	FT	Apatite
80	Cross Creek Granite	87N4	39 31 48	106 22 50	Eagle	Minturn	FT	Apatite
81	Cross Creek Granite	87N4	39 31 48	106 22 50	Eagle	Minturn	FT	Zircon
82	Pando Porphyry	Gil 47	39 31 45	106 22 30	Eagle	Red Cliff	FT	Zircon
83	Pando Porphyry	Gil 17	39 31 43	106 23 22	Eagle	Minturn	FT	Zircon
84	Fulford stock	I-22	39 31 40	106 39 28	Eagle	Fulford	K-Ar	Biotite
85	Cross Creek Granite	Gil 13	39 31 40	106 23 17	Eagle	Minturn	FT	Apatite
86	Cross Creek Granite	Gil 13	39 31 40	106 23 17	Eagle	Minturn	FT	Zircon
87	Fulford stock	Fulford-1	39 31 36	106 39 28	Eagle	Fulford	FT	Zircon
88	Cross Creek Granite	Gil 12	39 31 22	106 23 30	Eagle	Minturn	FT	Apatite
89	Cross Creek Granite	Gil 12	39 31 22	106 23 30	Eagle	Minturn	FT	Zircon
90	Pando Porphyry	Gil 18	39 31 22	106 23 21	Eagle	Minturn	FT	Zircon
91	Pando Porphyry	Gil 4	39 31 05	106 22 58	Eagle	Minturn	FT	Zircon
92	Pando Porphyry	Gil 4	39 31 05	106 22 58	Eagle	Minturn	FT	Apatite
93	Pando Porphyry	Gil 8	39 31 03	106 21 38	Eagle	Red Cliff	FT	Apatite
94	Pando Porphyry	Gil 8	39 31 03	106 21 38	Eagle	Red Cliff	FT	Zircon
95	Cross Creek Granite	Gil 11	39 31 02	106 23 27	Eagle	Minturn	FT	Apatite
96	Cross Creek Granite	Gil 11	39 31 02	106 23 27	Eagle	Minturn	FT	Zircon
97	Cross Creek Granite	—	39 31 00	106 30 05	Eagle	Grouse Mountain	Rb-Sr	Whole rock
98	Cross Creek Granite	Gil 19	39 30 50	106 23 10	Eagle	Minturn	FT	Apatite
99	Cross Creek Granite	Gil 19	39 30 50	106 23 10	Eagle	Minturn	FT	Zircon
100	Pando Porphyry	Gil 9	39 30 40	106 22 43	Eagle	Minturn	FT	Zircon
101	Cross Creek Granite	Gil 20	39 30 35	106 23 02	Eagle	Minturn	FT	Apatite
102	Cross Creek Granite	Gil 20	39 30 35	106 23 02	Eagle	Minturn	FT	Zircon
103	Unnamed diorite	Gil 10	39 30 30	106 22 32	Eagle	Minturn	FT	Apatite
104	Unnamed diorite	Gil 10	39 30 30	106 22 32	Eagle	Minturn	FT	Zircon
105	Granite gneiss	CO-36	39 30 20	106 22 40	Eagle	Red Cliff	Rb-Sr	Whole rock
106	Migmatite	C-6	39 30 20	106 22 40	Eagle	Minturn	Pb-alpha	Zircon
107	Migmatite	C-6	39 30 20	106 22 40	Eagle	Minturn	K-Ar	Biotite
108	Cross Creek Granite dike.	CO-37	39 29 30	106 22 15	Eagle	Pando	Rb-Sr	Whole rock
109	Pando Porphyry	T-4	39 29 16	106 21 02	Eagle	Pando	FT	Apatite
110	Pando Porphyry	T-4	39 29 16	106 21 02	Eagle	Pando	FT	Zircon
111	Cross Creek Granite	W3122	39 29 00	106 32 00	Eagle	Mt. Jackson	FT	Apatite
112	East Lake Creek stock	DF-849	39 28 36	106 33 20	Eagle	Mt. Jackson	FT	Zircon
113	East Lake Creek stock	DF-848	39 28 36	106 33 20	Eagle	Mt. Jackson	FT	Sphene
114	Tucker Mountain quartz monzonite.	90N2	39 27 38	106 10 10	Summit	Copper Mountain	FT	Apatite
115	Elk Mountain Porphyry	67-1	39 27 38	106 10 10	Summit	Copper Mountain	K-Ar	Biotite
116	Tucker Mountain quartz monzonite.	90N2	39 27 38	106 10 10	Summit	Copper Mountain	FT	Zircon
117	Migmatite	W3124	39 27 35	106 33 45	Eagle	Mt. Jackson	FT	Apatite
118	Silver Plume Granite	—	39 27 30	106 20 00	Eagle	Pando	K-Ar	Biotite
119	Quartz latite dike	W3127	39 27 28	106 34 30	Eagle	Mt. Jackson	K-Ar	Biotite
120	Lincoln Porphyry	67-2	39 27 25	106 10 30	Summit	Copper Mountain	K-Ar	Biotite
121	Tucker Mountain quartz monzonite.	—	39 27 25	106 10 30	Summit	Copper Mountain	K-Ar	Biotite
122	Quartz latite porphyry	90N1	39 27 18	106 10 11	Summit	Copper Mountain	FT	Zircon
123	Tucker Mountain rhyolite porphyry.	90N3	39 27 10	106 10 20	Summit	Copper Mountain	FT	Zircon
124	Tucker Mountain rhyolite porphyry.	—	39 27 10	106 10 15	Summit	Copper Mountain	K-Ar	Sanidine(?)
125	Humbug stock	USGS(D)-MG-4	39 27 00	106 09 00	Summit	Copper Mountain	K-Ar	Biotite
126	Humbug stock	USGS(D)-K150	39 27 00	106 06 00	Summit	Breckenridge	K-Ar	Biotite

Age (Ma)	Analytical uncertainty	Source of date	Geologic reference	Mining district	Comment
994	150	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
48.3	11	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
766	180	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
11.4	1	Larson and others (1975)	Tweto and others (1978)		Recalculated.
40.1	24	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
Proterozoic		Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
32.9	4.5	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
562	84	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
550	71	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
29.7	4.9	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
43.1	10	A. Wallace and C. Naeser, unpub. data, 1986.	Wallace and others (1986)		Date reflects uplift; 11,200 ft.
25.5	5.7	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
43.5	14	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
39.6	11	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
500	96	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
55.2	6.6	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
52.5	5	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
62.2	1.5	Cunningham and others (1977)	Wallace and others (1986)		
58	21	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
Proterozoic		Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
65.3	6	Cunningham and others (1977)	Wallace and others (1986)		
39.8	18	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
904	250	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
46.6	5.8	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
53	7.9	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
69	34	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
41.1	32	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
60.1	7.8	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
41.5	11	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
771	170	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
1,710		Tweto and Lovering (1977)	Tweto and Lovering (1977)		Six-point isochron; location only approximate.
44.2	10	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
877	200	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
58.9	7	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
50.8	24	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
Proterozoic		Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
46.7	19	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
758	11	Beaty and others (1990a)	Tweto and Lovering (1977)	Gilman	
1,650	35	Wetherill and Bickford (1965)	Tweto (1974)		Date based on isochron using several samples.
1,280	14	Pearson and others (1966)	Tweto and Lovering (1977)		
1,368	68	Pearson and others (1966)	Tweto and Lovering (1977)		Recalculated.
1,650	9	Wetherill and Bickford (1965)	Tweto (1974)		Date based on isochron using several samples.
48.6	26.3	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
53.2	6.2	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
55.9	20	A. Wallace and C. Naeser, unpub. data, 1986.	Wallace and Blaskowski (1989)		Date reflects uplift; top of Mt. Jackson (13,670 ft).
59.7	7.5	Cunningham and others (1977)	Wallace and Blaskowski (1989)		
65.3	5.5	Cunningham and others (1977)	Wallace and Blaskowski (1989)		
36.7	3.8	Mach (1992)	Mach (1992)	Kokomo	Likely reset during mineralization.
37.6	1.6	Brumbaugh (1976)	Mach (1992)	Kokomo	Pyritized sill.
41.8	3	Mach (1992)	Mach (1992)	Kokomo	Likely reset during mineralization.
65.9	23	A. Wallace and C. Naeser, unpub. data, 1986.	Wallace and Blaskowski (1989)		Date reflects uplift of Sawatch Range; 10,800 ft.
1,150	30	Marvin and Dobson (1979)	Tweto and Lovering (1977)		Date too young.
62.2	1.7	Marvin and others (1989)	Wallace and Blaskowski (1989)		
41	2.1	Brumbaugh (1976)	Mach (1992)	Kokomo	Feldspar sericitized; near margin of Tucker Mtn. stock.
43.9	2	Marvin and others (1974)	Tweto and others (1978)	Kokomo	Recalculated age; likely reset during mineralization.
38.3	4.4	Mach (1992)	Mach (1992)	Kokomo	Date too young; cut by Elk Mountain Porphyry (>66 Ma).
39.5	4.5	Mach (1992)	Mach (1992)	Kokomo	Contains skarn fragments that formed at about 40 Ma.
36.1	1.4	Marvin and others (1974)	Tweto and others (1978)	Kokomo	Recalculated; contains skarn fragments formed at about 40 Ma.
42.4	1	Marvin and Dobson (1979)	Tweto and others (1978)	Kokomo	Date too young: cut by 66-Ma Lincoln Porphyry (Bergendahl, 1963).
41.5	1	Marvin and Dobson (1979)	Tweto and others (1978)	Kokomo	Cut by Lincoln Porphyry (Bergendahl and Koschmann, 1971).

Appendix A. Summary of isotopic geochronology and related information, Leadville 1°x2° quadrangle, Colorado—Continued

Map No.	Unit name	Sample No.	Latitude (N.)	Longitude (W.)	County	7-1/2-minute quadrangle	Method	Mineral
127	Humbug stock	—	39 26 40	106 10 00	Summit	Copper Mountain	K-Ar	Biotite
128	Humbug stock	—	39 26 40	106 09 45	Summit	Copper Mountain	K-Ar	Biotite
129	Humbug stock	—	39 26 40	106 08 20	Summit	Copper Mountain	K-Ar	Biotite
130	Humbug stock	—	39 26 40	106 08 20	Summit	Copper Mountain	K-Ar	Biotite
131	Basalt	—	39 26 29	107 02 36	Eagle	Leon	K-Ar	Whole rock
132	Lincoln Porphyry	90N4	39 26 06	106 11 48	Summit	Copper Mountain	FT	Apatite
133	Lincoln Porphyry	90N4	39 26 06	106 11 48	Summit	Copper Mountain	FT	Zircon
134	Paragneiss	C-16	39 26 00	106 23 45	Eagle	Mt. of the Holy Cross	K-Ar	Biotite
135	Paragneiss	C-16	39 26 00	106 23 45	Eagle	Mt. of the Holy Cross	Pb-alpha	Zircon
136	Quartz latite dike	USGS(D)-72-92	39 26 00	106 19 00	Eagle	Pando	K-Ar	Sericite
137	West Cross Creek diorite.	W3123	39 25 40	106 32 15	Eagle	Mt. Jackson	FT	Apatite
138	West Cross Creek stock.	DF-850	39 25 40	106 32 15	Eagle	Mt. Jackson	FT	Zircon
139	West Cross Creek stock.	D2499B	39 25 40	106 32 15	Eagle	Mt. Jackson	K-Ar	Biotite
140	Lincoln Porphyry	87N15	39 25 23	106 11 25	Summit	Copper Mountain	FT	Zircon
141	Lincoln Porphyry	87N15	39 25 23	106 11 25	Summit	Copper Mountain	FT	Apatite
142	Basalt	—	39 25 21	107 08 58	Garfield	Carbondale	K-Ar	Whole rock
143	Granite of Holy Cross City.	C-22	39 25 15	106 29 45	Eagle	Mt. of the Holy Cross	K-Ar	Biotite
144	Granite of Holy Cross City.	C-22	39 25 15	106 29 45	Eagle	Mt. of the Holy Cross	Pb-alpha	Zircon
145	Migmatite	C-23	39 25 15	106 28 45	Eagle	Mt. of the Holy Cross	K-Ar	Biotite
146	Migmatite	C-23	39 25 15	106 28 45	Eagle	Mt. of the Holy Cross	K-Ar	Muscovite
147	Migmatite	C-23	39 25 15	106 28 45	Eagle	Mt. of the Holy Cross	Pb-alpha	Zircon
148	Mylonite	C-24	39 25 10	106 28 35	Eagle	Mt. of the Holy Cross	K-Ar	Whole rock
149	Biotite rhyolite-B porphyry.	1323-AB-82-1	39 25 09	106 16 09	Eagle	Pando	FT	Zircon
150	Biotite rhyolite-B porphyry.	1323-AB-82-1	39 25 09	106 16 09	Eagle	Pando	K-Ar	Sanidine
151	Biotite rhyolite-B porphyry.	1323-AB-82-1	39 25 09	106 16 09	Eagle	Pando	K-Ar	Biotite
152	Quail Porphyry	87N13	39 25 07	106 11 54	Summit	Copper Mountain	FT	Apatite
153	Quail Porphyry	87N13	39 25 07	106 11 54	Summit	Copper Mountain	FT	Zircon
154	Quail Porphyry	90N5	39 25 07	106 11 48	Summit	Copper Mountain	FT	Apatite
155	Quail Porphyry	90N5	39 25 07	106 11 48	Summit	Copper Mountain	FT	Zircon
156	Quail Porphyry	87N14	39 25 04	106 11 55	Summit	Copper Mountain	FT	Zircon
157	Quail Porphyry	87N14	39 25 04	106 11 55	Summit	Copper Mountain	FT	Apatite
158	Elk Mountain Porphyry	87N16	39 25 04	106 11 53	Summit	Copper Mountain	FT	Zircon
159	Elk Mountain Porphyry	87N16	39 25 04	106 11 53	Summit	Copper Mountain	FT	Apatite
160	Basalt	—	39 24 35	107 05 52	Eagle	Leon	K-Ar	Whole rock
161	Treasure Vault stock	83P100	39 24 33	106 31 17	Eagle	Mt. Jackson	K-Ar	Biotite
162	Treasure Vault stock	83P100	39 24 33	106 31 17	Eagle	Mt. Jackson	FT	Apatite
163	Treasure Vault stock	83P100	39 24 33	106 31 17	Eagle	Mt. Jackson	FT	Zircon
164	Elk Mountain Porphyry	87N12	39 24 03	106 12 28	Summit	Copper Mountain	FT	Apatite
165	Elk Mountain Porphyry	87N12	39 24 03	106 12 28	Summit	Copper Mountain	FT	Zircon
166	Hornblendite	C-15	39 24 00	106 27 00	Eagle	Mt. of the Holy Cross	K-Ar	Biotite
167	Hornblendite	C-15	39 24 00	106 27 00	Eagle	Mt. of the Holy Cross	K-Ar	Hornblende
168	Climax mine	4550	39 24 00	106 12 00	Summit	Copper Mountain	Rb-Sr	Sericite
169	Gneiss	USGS(W)-2-D-622	39 23 50	106 30 15	Eagle	Mt. Jackson	K-Ar	Biotite
170	Lincoln Porphyry	T-40	39 23 37	106 15 51	Eagle	Pando	FT	Zircon
171	Lincoln Porphyry	T-40	39 23 37	106 15 51	Eagle	Pando	FT	Apatite
172	Lincoln Porphyry	T-40	39 23 37	106 15 51	Eagle	Pando	FT	Sphene
173	Paragneiss	C-8	39 23 30	106 29 45	Eagle	Mt. of the Holy Cross	K-Ar	Biotite
174	Paragneiss	C-8	39 23 30	106 29 45	Eagle	Mt. of the Holy Cross	Pb-alpha	Zircon
175	Pegmatite	C-19	39 23 30	106 19 00	Eagle	Pando	K-Ar	Muscovite
176	Missouri Creek stock	C-7	39 23 19	106 29 00	Eagle	Mt. of the Holy Cross	K-Ar	Biotite
177	Granodiorite	D-6	39 23 15	106 29 00	Eagle	Mt. of the Holy Cross	K-Ar	Biotite
178	Granodiorite	D-7	39 23 10	106 28 55	Eagle	Mt. of the Holy Cross	K-Ar	Biotite

Age (Ma)	Analytical uncertainty	Source of date	Geologic reference	Mining district	Comment
44.7	2.1	Marvin and others (1974)	Tweto and others (1978)	Kokomo	Recalculated; cut by 66-Ma Lincoln Porphyry (Bergendahl, 1963).
35.9	1.4	Marvin and others (1974)	Tweto and others (1978)	Kokomo	Recalculated; cut by 66-Ma Lincoln Porphyry (Bergendahl, 1963).
35.8	2	Marvin and others (1974)	Tweto and others (1978)	Kokomo	Recalculated; cut by 66-Ma Lincoln Porphyry (Bergendahl, 1963).
48	2.2	Marvin and others (1974)	Tweto and others (1978)	Kokomo	Recalculated; cut by 66-Ma Lincoln Porphyry (Bergendahl, 1963).
9.01	0.4	Larson and others (1975)	Tweto and others (1978)		Recalculated.
36.7	3.9	Mach (1992)	Mach (1992)	Kokomo	Date too young; intrusion age 66 Ma.
41.5	3.7	Mach (1992)	Mach (1992)	Kokomo	Date too young; intrusion age 66 Ma.
1,264	63	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,495	16	Pearson and others (1966)	Tweto (1974)		
63	1.5	Marvin and Dobson (1979)	Tweto (1974)		Date reflects post-intrusion alteration.
51.1	11	A. Wallace and C. Naeser, unpub. data, 1986.	Wallace and Blaskowski (1989)		Date reflects uplift; 12,080 ft.
59.3	6.2	Cunningham and others (1977)	Wallace and Blaskowski (1989)		Oldest part of Middle Mountain intrusive complex.
61.8	1.4	Cunningham and others (1977)	Wallace and Blaskowski (1989)		Oldest part of Middle Mountain intrusive complex.
40.1	3.9	Mach (1992)	Mach (1992)	Kokomo	Date too young; intrusion age 66 Ma.
48.6	6.6	Mach (1992)	Mach (1992)	Kokomo	Date too young; intrusion age 66 Ma.
8.91	0.4	Larson and others (1975)	Tweto and others (1978)		Recalculated.
1,184	59	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,630	18	Pearson and others (1966)	Tweto (1974)		
1,209	60	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,298	65	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,365	15	Pearson and others (1966)	Tweto (1974)		
332	16	Pearson and others (1966)	Tweto (1974)		Recalculated.
35.5	3.2	Bookstrom and others (1987)	Tweto (1974)	Tennessee Pass	Likely partially reset by Tennessee Pass hydrothermal system.
40.2	2	Bookstrom and others (1987)	Tweto (1974)	Tennessee Pass	
43.5	3	Bookstrom and others (1987)	Tweto (1974)	Tennessee Pass	
41.6	10.4	Mach (1992)	Mach (1992)	Kokomo	Cut by 66-Ma Lincoln Porphyry (Bergendahl and Koschmann, 1971).
44.4	5.3	Mach (1992)	Mach (1992)	Kokomo	Cut by 66-Ma Lincoln Porphyry (Bergendahl and Koschmann, 1971).
45.3	8.3	Mach (1992)	Mach (1992)	Kokomo	Recalculated; cut by 66-Ma Lincoln Porphyry (Bergendahl, 1963).
51	5.1	Mach (1992)	Mach (1992)	Kokomo	Cut by 66-Ma Lincoln Porphyry (Bergendahl and Koschmann, 1971).
40.4	4.5	Mach (1992)	Mach (1992)	Kokomo	Cut by 66-Ma Lincoln Porphyry (Bergendahl and Koschmann, 1971).
46.1	8.2	Mach (1992)	Mach (1992)	Kokomo	Cut by 66-Ma Lincoln Porphyry (Bergendahl and Koschmann, 1971).
37.6	3.7	Mach (1992)	Mach (1992)	Kokomo	Cut by 66-Ma Lincoln Porphyry (Bergendahl and Koschmann, 1971).
51.5	12.3	Mach (1992)	Mach (1992)	Kokomo	Cut by 66-Ma Lincoln Porphyry (Bergendahl and Koschmann, 1971).
8.07	0.4	Larson and others (1975)	Tweto and others (1978)		Recalculated.
64	2.3	Marvin and others (1989)	Wallace and Blaskowski (1989)		Main porphyritic phase of intrusive complex.
52	15.7	R.C. Pearson, unpub. data, 1985	Wallace and Blaskowski (1989)		Date reflects uplift of Sawatch
69.4	7.2	R.C. Pearson, unpub. data, 1985	Wallace and Blaskowski (1989)		Range.
41.9	9.5	Mach (1992)	Mach (1992)	Kokomo	Cut by 66-Ma Lincoln Porphyry (Bergendahl and Koschmann, 1971).
50.9	5.2	Mach (1992)	Mach (1992)	Kokomo	Cut by 66-Ma Lincoln Porphyry (Bergendahl and Koschmann, 1971).
1,249	62	Pearson and others (1966)	Tweto (1974)		Recalculated.
2,018	10	Pearson and others (1966)	Tweto (1974)		Recalculated.
74.8	8	Marvin and others (1974)	White and others (1981)	Climax	Mixed rock from tailings.
483	24	Marvin and Dobson (1979)	Wallace and Blaskowski (1989)		Date too young.
39.9	3.6	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Weakly altered.
40.7	7.5	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Weakly altered.
43.7	6.6	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Weakly altered.
92.3	5	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,405	16	Pearson and others (1966)	Tweto (1974)		
1,368	68	Pearson and others (1966)	Tweto (1974)		Recalculated.
71.8		Pearson and others (1962)	Tweto (1974)		Recalculated.
64.6	3	Marvin and others (1974)	Tweto (1974)		Recalculated.
65.6	3	Marvin and others (1974)	Tweto (1974)		Recalculated.

Appendix A. Summary of isotopic geochronology and related information, Leadville 1°x2° quadrangle, Colorado—Continued

Map No.	Unit name	Sample No.	Latitude (N.)	Longitude (W.)	County	7-1/2-minute quadrangle	Method	Mineral
179	Missouri Creek granodiorite.	C-7	39 23 00	106 29 00	Eagle	Mt. of the Holy Cross	K-Ar	Biotite
180	Pegmatite	C-18	39 23 00	106 20 00	Eagle	Pando	K-Ar	Muscovite
181	Eagle River Porphyry	T-41	39 22 56	106 18 32	Eagle	Pando	FT	Zircon
182	Eagle River Porphyry	T-41	39 22 56	106 18 32	Eagle	Pando	FT	Apatite
183	Lincoln Porphyry	T-38	39 22 44	106 14 09	Eagle	Copper Mountain	FT	Apatite
184	Lincoln Porphyry	T-38	39 22 44	106 14 09	Eagle	Copper Mountain	FT	Zircon
185	Lincoln Porphyry	66-283	39 22 40	106 08 30	Summit	Copper Mountain	K-Ar	Biotite
186	Lincoln Porphyry	66-282	39 22 30	106 08 45	Lake	Copper Mountain	K-Ar	Biotite
187	Metalamprophyre	C-17	39 22 25	106 23 40	Lake	Homestake Reservoir	K-Ar	Biotite
188	Paragneiss	C-9	39 22 25	106 18 40	Eagle	Pando	Pb-alpha	Zircon
189	Paragneiss	C-9	39 22 25	106 18 40	Eagle	Pando	K-Ar	Biotite
190	Chalk Mountain Rhyolite	—	39 22 24	106 12 40	Lake	Climax	K-Ar	Biotite
191	Climax sericite	4550	39 22 24	106 09 41	Lake	Climax	Rb-Sr	Sericite
192	Climax–"Central Mass"	1683-623	39 22 24	106 09 41	Lake	Climax	FT	Zircon
193	Climax–biotite rhyolite porphyry.	1619-600	39 22 24	106 09 41	Lake	Climax	FT	Zircon
194	Climax–late barren stage sericite.	—	39 22 24	106 09 41	Lake	Climax	K-Ar	Sericite
195	Climax–late rhyolite porphyry.	76-15	39 22 24	106 09 41	Lake	Climax	FT	Zircon
196	Climax–Precambrian granite.	B-230	39 22 24	106 09 41	Lake	Climax	K-Ar	Biotite
197	Climax–Precambrian granite.	B-232	39 22 24	106 09 41	Lake	Climax	K-Ar	Biotite
198	Climax–Rhyolite porphyry.	77-821	39 22 24	106 09 41	Lake	Climax	FT	Zircon
199	Climax–Seriate granite stock.	Climax 78-1	39 22 24	106 09 41	Lake	Climax	FT	Zircon
200	Climax–Seriate granite stock.	1650-525	39 22 24	106 09 41	Lake	Climax	FT	Zircon
201	Climax–upper ore body sericite.	—	39 22 24	106 09 41	Lake	Climax	K-Ar	Sericite
202	Lincoln Porphyry	66-281	39 22 24	106 09 41	Lake	Climax	K-Ar	Biotite
203	Lincoln Porphyry	T-2	39 22 13	106 17 24	Eagle	Leadville North	FT	Zircon
204	Lincoln Porphyry	T-2	39 22 13	106 17 24	Eagle	Leadville North	FT	Apatite
205	Climax porphyritic granite.	G-MO146	39 22 00	106 10 00	Lake	Climax	K-Ar	Muscovite
206	Lincoln Porphyry	25T56	39 21 00	106 07 00	Park	Alma	Rb-Sr	Whole rock
207	Lincoln Porphyry	T-5	39 20 54	106 16 24	Lake	Leadville North	FT	Zircon
208	West Tennessee Creek stock.	—	39 20 48	106 25 25	Lake	Homestake Reservoir	FT	Apatite
209	West Tennessee Creek stock.	—	39 20 48	106 25 25	Lake	Homestake Reservoir	K-Ar	Biotite
210	Grizzly Peak Tuff (outflow).	USGS(D)-A	39 20 47	107 06 02	Pitkin	Basalt	FT	Zircon
211	Grizzly Peak Tuff (outflow).	USGS(D)-A	39 20 47	107 06 02	Pitkin	Basalt	FT	Zircon
212	Grizzly Peak Tuff (outflow).	USGS(D)-A	39 20 47	107 06 02	Pitkin	Basalt	K-Ar	Biotite
213	Lincoln Porphyry	T-42	39 20 45	106 16 18	Lake	Leadville North	FT	Apatite
214	Lincoln Porphyry	T-42	39 20 45	106 16 18	Lake	Leadville North	FT	Zircon
215	Lincoln Porphyry	T-42	39 20 45	106 16 18	Lake	Leadville North	FT	Sphene
216	Lincoln Porphyry	C-10	39 20 30	106 13 30	Lake	Climax	K-Ar	Biotite
217	Lincoln Porphyry	C-10	39 20 30	106 13 30	Lake	Climax	Pb-alpha	Zircon
218	Pando Porphyry	T-1	39 20 09	106 17 52	Lake	Leadville North	FT	Zircon
219	Pando Porphyry	T-1	39 20 09	106 17 52	Lake	Leadville North	FT	Apatite
220	Buckskin porphyritic rhyolite-A dike.	BU-77-H-100	39 20 08	106 07 47	Park	Climax	FT	Zircon
221	Granodiorite stock	—	39 20 02	106 07 50	Park	Climax	K-Ar	Biotite
222	St. Kevin Granite	C-20	39 20 00	106 23 45	Lake	Homestake Reservoir	K-Ar	Biotite
223	St. Kevin Granite	C-20	39 20 00	106 23 45	Lake	Homestake Reservoir	Rb-Sr	Biotite
224	St. Kevin Granite	C-20	39 20 00	106 23 45	Lake	Homestake Reservoir	Rb-Sr	Muscovite
225	St. Kevin Granite	C-20	39 20 00	106 23 45	Lake	Homestake Reservoir	K-Ar	Muscovite
226	St. Kevin Granite	C-20	39 20 00	106 23 45	Lake	Homestake Reservoir	Rb-Sr	K feldspar
227	St. Kevin Granite	C-20	39 20 00	106 23 45	Lake	Homestake Reservoir	Rb-Sr	Whole rock

Age (Ma)	Analytical uncertainty	Source of date	Geologic reference	Mining district	Comment
70.8	3	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,343	67	Pearson and others (1966)	Tweto (1974)		Recalculated.
52.9	6	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
54.5	17	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
34.9	7.1	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Weakly altered.
42.1	4.3	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Weakly altered.
51.3	5	Brumbaugh (1976)	White and others (1981)	Climax	Dike 5,000 ft from 0.1% molybdenite zone.
29.8	2	Brumbaugh (1976)	White and others (1981)	Climax	Dike 840 ft from 0.1% molybdenite zone.
1,328	66	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,170	13	Pearson and others (1966)	Tweto (1974)		
1,358	68	Pearson and others (1966)	Tweto (1974)		Recalculated.
27.7	1.9	Marvin and others (1974)	White and others (1981)	Climax	Unrecalculated date of 27 Ma reported in White and others (1981).
73	8	Moorbath and others (1967)	White and others (1981)		Date too old based upon more recent geochronology.
23.3	1.1	Smith (1979)	White and others (1981)	Climax	Date too young: unit cut by dikes related to Chalk Mountain Rhyolite.
26.1	1.2	Smith (1979)	White and others (1981)	Climax	
25.3	0.3	White and others (1981)	White and others (1981)	Climax	
25.5	1.2	Smith (1979)	White and others (1981)	Climax	
74.9	2.3	Brumbaugh (1976)	White and others (1981)	Climax	Reset by Climax intrusive system.
96.4	2.9	Brumbaugh (1976)	White and others (1981)	Climax	Reset by Climax intrusive system.
33.2	2.1	Smith (1979)	White and others (1981)	Climax	Dates of individual grains range from 17 to 50 Ma.
24.4	4.9	Bookstrom and others (1987)	White and others (1981)	Climax	
18.2	0.9	Smith (1979)	White and others (1981)	Climax	Too young: may reflect annealing by unexposed stock.
30.6	0.4	White and others (1981)	White and others (1981)	Climax	Recalculated.
30.8	2	Brumbaugh (1976)	White and others (1981)	Climax	Dike within 0.1% molybdenite zone; reset by Climax intrusive system.
38.2	3.5	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Fresh rock.
56.4	11.1	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Fresh rock.
30.3	1	Schassberger (1972)	White and others (1981)	Climax	Recalculated.
67		Simmons and Hedge (1978)	Tweto and others (1978)	Alma	Sample outside area of strong hydrothermal effects (Bookstrom, 1989).
39.5	4	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Intensely altered.
46.4	9.8	Cunningham and others (1977)	Tweto (1974)		
66.4	2.2	Cunningham and others (1977)	Tweto (1974)		
30.1	3	Marvin and Dobson (1979)	Fridrich (1986)		
30.2	0.9	Marvin and Dobson (1979)	Fridrich (1986)		
36.3	0.9	Marvin and Dobson (1979)	Fridrich (1986)		Also reported in Marvin and Cole (1978).
42	7.6	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
43.3	4.2	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Appears fresh, but date reset.
49.3	8	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Appears fresh, but date reset.
65.6		Pearson and others (1962)	Tweto (1974)		Recalculated.
530	60	Pearson and others (1962)	Tweto (1974)		Pb-alpha date too old; zircon may be xenocrystic.
67.7	7.7	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Intensely altered.
72.7	23.9	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Intensely altered.
34.9	4	Bookstrom and others (1987)	Tweto and others (1978)	Alma	
42.1	1.2	Bookstrom (1989)	Bookstrom (1989)	Alma	
1,209	60	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,260	63	Pearson and others (1966)	Tweto (1974)		
1,290	65	Pearson and others (1966)	Tweto (1974)		
1,358	68	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,430	13	Pearson and others (1966)	Tweto (1974)		
1,436	72	Pearson and others (1966)	Tweto (1974)		Recalculated whole-rock date using data in Pearson and others (1966).

Appendix A. Summary of isotopic geochronology and related information, Leadville 1°x2° quadrangle, Colorado—Continued

Map No.	Unit name	Sample No.	Latitude (N.)	Longitude (W.)	County	7-1/2-minute quadrangle	Method	Mineral
228	Buckskin Gulch leucogranite.	USGS(D)-LG-15	39 20 00	106 07 20	Park	Alma	K-Ar	Biotite
229	Syenodiorite	T-43	39 19 57	106 15 12	Lake	Leadville North	FT	Apatite
230	Syenodiorite	T-43	39 19 57	106 15 12	Lake	Leadville North	FT	Zircon
231	Syenodiorite	T-43	39 19 57	106 15 12	Lake	Leadville North	FT	Sphene
232	Sacramento Porphyry	T-39	39 19 57	106 12 33	Lake	Climax	FT	Apatite
233	Sacramento Porphyry	T-39	39 19 57	106 12 33	Lake	Climax	FT	Zircon
234	Buckskin Gulch granodiorite.	—	39 19 47	106 07 28	Park	Alma	K-Ar	Biotite
235	St. Kevin Granite	D-1419	39 19 40	106 25 00	Lake	Homestake Reservoir	Rb-Sr	Whole rock
236	Buckskin biotite granodiorite dike.	KL-1-2134	39 19 40	106 07 47	Park	Climax	FT	Zircon
237	Buckskin porphyritic rhyolite-B dike.	BU-77-H-98	39 19 38	106 07 14	Park	Alma	FT	Zircon (avg.3).
238	Buckskin porphyritic rhyolite-B dike.	BU-77-H-98	39 19 38	106 07 14	Park	Alma	FT	Zircon (avg.7).
239	Buckskin porphyritic rhyolite-B dike.	BU-77-H-98	39 19 38	106 07 14	Park	Alma	FT	Zircon (avg.4).
240	Biotite granodiorite stock.	—	39 19 30	106 07 00	Park	Climax	K-Ar	Biotite
241	Lincoln Porphyry	T-44	39 19 16	106 14 59	Lake	Climax	FT	Apatite
242	Lincoln Porphyry	T-44	39 19 16	106 14 59	Lake	Climax	FT	Zircon
243	Buckskin Gulch dacite.	USGS(D)-HBD-4	39 19 00	106 07 45	Park	Climax	K-Ar	Biotite
244	Buckskin Gulch melagranodiorite.	USGS(D)-MG-4	39 19 00	106 07 35	Park	Climax	K-Ar	Biotite
245	Quartz monzonite stock.	—	39 19 00	106 07 32	Park	Climax	K-Ar	Biotite
246	Lincoln Porphyry	L-1125	39 18 51	106 13 35	Lake	Climax	K-Ar	Biotite
247	St. Kevin Granite	C-25	39 18 50	106 25 30	Lake	Homestake Reservoir	K-Ar	Biotite
248	St. Kevin Granite	C-25	39 18 50	106 25 30	Lake	Homestake Reservoir	Pb-alpha	Zircon
249	St. Kevin Granite	D-1418	39 18 50	106 25 30	Lake	Homestake Reservoir	Rb-Sr	Whole rock
250	Pando Porphyry	T-6	39 18 35	106 17 19	Lake	Leadville North	FT	Zircon
251	Basalt, nepheline-normative.	—	39 18 18	106 54 53	Pitkin	Woody Creek	K-Ar	Whole rock
252	Basalt, nepheline-normative.	—	39 18 16	106 54 53	Pitkin	Woody Creek	K-Ar	Whole rock
253	Pando Porphyry	T-7	39 18 09	106 16 57	Lake	Leadville North	FT	Zircon
254	Pando Porphyry	C-12	39 18 00	106 15 30	Lake	Leadville North	K-Ar	Biotite
255	Treasurevault stock	—	39 18 00	106 10 00	Park	Climax	K-Ar	Biotite(?)
256	Pando Porphyry	C-12	39 17 55	106 15 30	Lake	Leadville North	FT	Zircon
257	Timberline Lake latite breccia.	—	39 17 30	106 28 40	Lake	Homestake Reservoir	K-Ar	Sericite
258	Paragneiss	C-1	39 17 00	106 26 15	Lake	Homestake Reservoir	K-Ar	Biotite
259	St. Kevin Granite	HWDT	39 17 00	106 26 15	Lake	Homestake Reservoir	U-Th-Pb	Zircon
260	Turquoise Lake porphyry	—	39 16 38	106 24 21	Lake	Homestake Reservoir	K-Ar	Sericite
261	Mount Sopris stock	DF-1104	39 16 13	107 08 43	Pitkin	Mount Sopris	FT	Zircon
262	Mount Sopris stock	D2552B	39 16 13	107 08 43	Pitkin	Mount Sopris	K-Ar	Biotite
263	Sacramento Porphyry	CSU-1	39 15 45	106 12 30	Lake	Climax	FT	Zircon
264	Johnson Gulch Porphyry	C-21	39 15 40	106 16 10	Lake	Leadville North	K-Ar	Biotite
265	Johnson Gulch Porphyry	C-21	39 15 40	106 16 10	Lake	Leadville North	Pb-alpha	Zircon
266	St. Kevin Granite	C-2	39 15 30	106 27 35	Lake	Homestake Reservoir	U-Th-Pb	Zircon
267	St. Kevin Granite	C-2	39 15 30	106 27 35	Lake	Homestake Reservoir	Pb-alpha	Zircon
268	St. Kevin Granite	C-2	39 15 30	106 27 00	Lake	Homestake Reservoir	K-Ar	Biotite
269	St. Kevin Granite	E-2208	39 15 30	106 27 00	Lake	Homestake Reservoir	Rb-Sr	Whole rock
270	St. Kevin Granite	D-1773	39 15 20	106 29 30	Pitkin	Homestake Reservoir	Rb-Sr	Whole rock
271	Johnson Gulch Porphyry	C-13	39 15 20	106 15 05	Lake	Leadville North	Pb-alpha	Zircon
272	Evans Gulch Porphyry	—	39 15 18	106 14 28	Lake	Climax	FT	Zircon
273	St. Kevin Granite	C-3	39 15 15	106 28 35	Lake	Homestake Reservoir	U-Th-Pb	Zircon
274	St. Kevin Granite	C-3	39 15 15	106 28 35	Lake	Homestake Reservoir	K-Ar	Biotite
275	St. Kevin Granite	C-3	39 15 15	106 28 35	Lake	Homestake Reservoir	Rb-Sr	Biotite
276	St. Kevin Granite	C-3	39 15 15	106 28 35	Lake	Homestake Reservoir	Rb-Sr	K feldspar
277	St. Kevin Granite	C-3	39 15 15	106 28 35	Lake	Homestake Reservoir	Rb-Sr	Whole rock
278	St. Kevin Granite	E-2209	39 15 10	106 25 30	Lake	Homestake Reservoir	Rb-Sr	Whole rock

Age (Ma)	Analytical uncertainty	Source of date	Geologic reference	Mining district	Comment
66.7	1.6	Marvin and Dobson (1979)	Kuntz (1968)	Alma	Date may be slightly young: cut by 69.9-Ma dacite (USGS(D)-HBD-4).
44.2	13	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
48.4	4.9	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
64.7	18	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
45.2	19	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Fresh rock.
53.6	6	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Fresh rock.
62.4	1.9	Bookstrom (1989)	Bookstrom (1989)	Alma	
1,436	72	Pearson and others (1966)	Tweto (1974)		Recalculated whole-rock date using data in Pearson and others (1966).
27.6	3	Bookstrom and others (1987)	Tweto and others (1978)	Alma	Chloritic alteration.
26.7	4	Bookstrom and others (1987)	Tweto and others (1978)	Alma	Average of younger 3 grains; reset by inferred Climax-age system beneath Mt. Bross.
35.4	3.3	Bookstrom and others (1987)	Tweto and others (1978)	Alma	Average of 7 grains.
43.9	5.6	Bookstrom and others (1987)	Tweto and others (1978)	Alma	Average of older 4 grains; intrusion and cooling.
55.9	2.5	Bookstrom (1989)	Bookstrom (1989)	Alma	
48.3	17	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
73.6	8.2	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
69.9	1.7	Marvin and Dobson (1979)	Kuntz (1968)	Alma	Date slightly old: cuts 66.7-Ma leucogranodiorite.
71.2	1.7	Marvin and Dobson (1979)	Kuntz (1968)	Alma	Supercedes date in Marvin and others (1974).
71.4	2.4	A. Bookstrom, unpub. data, 1989.	Bookstrom (1989)	Alma	Dated by T. Heidrick and C. Hedge; data from A. Bookstrom.
66.3	1.9	McDowell (1971)	Tweto and others (1974)		Recalculated.
1,309	65	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,362	15	Pearson and others (1966)	Tweto (1974)		
1,436	72	Pearson and others (1966)	Tweto (1974)		Recalculated whole-rock date using data in Pearson and others (1966).
60.6	6.8	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Intensely altered.
1.28	0.2	Larson and others (1975)	Tweto and others (1978)		Recalculated.
2.03	0.3	Larson and others (1975)	Tweto and others (1978)		Recalculated.
55.5	5.6	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Moderately altered.
71.8		Pearson and others (1962)	Tweto (1974)		Recalculated.
1,430	45	C. Hedge, unpub. data	Kuntz and Brock (1977)		
61.1	6.3	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Weakly altered.
35.9	1.2	Tweto (1974)	Tweto (1974)		Recalculated.
1,240	62	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,411	40	Doe and Pearson (1969)	Tweto (1974)		Upper-intercept date from data in Doe and Pearson (1969).
35.6	1.4	Craig (1980)	Craig (1980); Tweto (1974)		Originally mapped as Lincoln Porphyry (Tweto, 1974).
34.2	3.7	Cunningham and others (1977)	Tweto and others (1978)		
34.2	0.8	Cunningham and others (1977)	Tweto and others (1978)		
43.9	4.3	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Fresh; location approximate.
42.1		Pearson and others (1962)	Tweto (1974)		Recalculated; date too young based upon geologic relations.
120	20	Pearson and others (1962)	Tweto (1974)		Zircons xenocrystic.
1,411	40	Doe and Pearson (1969)	Tweto (1974)		Upper-intercept date from data in Doe and Pearson (1969).
1,505	17	Pearson and others (1966)	Tweto (1974)		
1,210	61	Pearson and others (1966)	Tweto (1974)		
1,436	72	Pearson and others (1966)	Tweto (1974)		Recalculated whole-rock date using data in Pearson and others (1966).
1,436	72	Pearson and others (1966)	Tweto (1974)		Recalculated whole-rock date using data in Pearson and others (1966).
130	20	Pearson and others (1962)	Tweto (1974)		Zircons xenocrystic.
47	3.9	Cunningham and others (1977)	Behre (1953)	Leadville	White Cloud mine, Leadville.
1,411	40	Doe and Pearson (1969)	Tweto (1974)		Upper-intercept date from data in Doe and Pearson (1969).
1,239	62	Pearson and others (1966)	Tweto (1974)		Recalculated.
1,250	63	Pearson and others (1966)	Tweto (1974)		
1,310	13	Pearson and others (1966)	Tweto (1974)		
1,436	72	Pearson and others (1966)	Tweto (1974)		Recalculated whole-rock date using data in Pearson and others (1966).
1,436	72	Pearson and others (1966)	Tweto (1974)		Recalculated whole-rock date using data in Pearson and others (1966).

Appendix A. Summary of isotopic geochronology and related information, Leadville 1°x2° quadrangle, Colorado—Continued

Map No.	Unit name	Sample No.	Latitude (N.)	Longitude (W.)	County	7-1/2-minute quadrangle	Method	Mineral
279	Rhyolite porphyry (Eureka pipe).	D2642S	39 15 03	106 14 45	Lake	Climax	K-Ar	Sanidine
280	Evans Gulch Porphyry	31T55	39 15 00	106 15 00	Lake	Leadville North	Rb-Sr	Whole rock
281	Johnson Gulch Porphyry	90T53	39 15 00	106 14 00	Lake	Climax	Rb-Sr	Whole rock
282	Johnson Gulch Porphyry	FT-4	39 14 20	106 14 00	Lake	Mt. Sherman	FT	Apatite
283	Johnson Gulch Porphyry	FT-6	39 14 20	106 14 00	Lake	Mt. Sherman	FT	Zircon
284	Johnson Gulch Porphyry	FT-4	39 14 20	106 14 00	Lake	Mt. Sherman	FT	Zircon
285	Johnson Gulch Porphyry	CSU-11	39 14 15	106 13 45	Lake	Mt. Sherman	FT	Zircon
286	Johnson Gulch Porphyry	CSU-10	39 14 15	106 13 45	Lake	Mt. Sherman	FT	Zircon
287	Quartz monzonite	1371	39 14 09	106 45 05	Pitkin	Aspen	FT	Apatite
288	Johnson Gulch Porphyry	—	39 14 00	106 14 15	Lake	Mt. Sherman	K-Ar	Sericite
289	Johnson Gulch Porphyry	FT-10	39 13 33	106 14 30	Lake	Mt. Sherman	FT	Apatite
290	Johnson Gulch Porphyry	FT-10	39 13 33	106 14 30	Lake	Mt. Sherman	FT	Zircon
291	Pando Porphyry	4233	39 13 30	106 13 40	Lake	Mt. Sherman	K-Ar	Sericite
292	Pando Porphyry	4233	39 13 30	106 13 40	Lake	Mt. Sherman	Rb-Sr	Whole rock
293	Johnson Gulch Porphyry	CSU-3	39 13 30	106 13 30	Lake	Mt. Sherman	FT	Zircon
294	Johnson Gulch Porphyry	CSU-4	39 13 30	106 13 30	Lake	Mt. Sherman	FT	Zircon
295	Johnson Gulch Porphyry	CSU-7	39 13 30	106 13 30	Lake	Mt. Sherman	FT	Zircon
296	Johnson Gulch Porphyry	CSU-6	39 13 30	106 13 30	Lake	Mt. Sherman	FT	Zircon
297	Johnson Gulch Porphyry	CSU-5	39 13 30	106 13 30	Lake	Mt. Sherman	FT	Zircon
298	Johnson Gulch Porphyry	CSU-9	39 13 30	106 13 30	Lake	Mt. Sherman	FT	Zircon
299	Johnson Gulch Porphyry	CSU-8	39 13 30	106 13 30	Lake	Mt. Sherman	FT	Zircon
300	Lincoln Porphyry	T-3	39 13 16	106 15 02	Lake	Leadville South	FT	Zircon
301	Lincoln Porphyry	T-3	39 13 16	106 15 02	Lake	Leadville South	FT	Apatite
302	Gothic Formation	AS-3	39 12 48	106 50 22	Pitkin	Aspen	FT	Zircon
303	Quartz latite dike	MM-35	39 12 30	106 29 38	Lake	Mt. Massive	K-Ar	Biotite
304	Granodiorite	D-10	39 11 59	106 46 28	Pitkin	Aspen	FT	Apatite
305	Maroon Formation	AS-4	39 11 46	106 49 35	Pitkin	Aspen	FT	Zircon
306	Aplite porphyry	AS-7	39 11 41	106 46 20	Pitkin	Aspen	FT	Zircon
307	Aplite porphyry	AS-5	39 11 40	106 48 12	Pitkin	Aspen	FT	Zircon
308	Aplite porphyry	AS-6	39 11 38	106 48 13	Pitkin	Aspen	FT	Zircon
309	Snowmass Creek sill	389	39 11 07	107 01 08	Pitkin	Capitol Peak	K-Ar	Biotite
310	Aplite porphyry	AS-8	39 10 47	106 49 14	Pitkin	Aspen	FT	Zircon
311	Quartz monzonite	AS-2	39 10 37	106 47 42	Pitkin	Aspen	FT	Apatite
312	Quartz monzonite	AS-2	39 10 37	106 47 42	Pitkin	Aspen	FT	Zircon
313	Quartz monzonite	AS-9	39 10 34	106 49 46	Pitkin	Aspen	FT	Apatite
314	Quartz latite dike	MM-54	39 09 40	106 31 43	Lake	Mount Champion	K-Ar	Biotite
315	Quartz porphyry	AS-12	39 08 25	106 49 23	Pitkin	Aspen	FT	Apatite
316	Quartz porphyry	AS-12	39 08 25	106 49 23	Pitkin	Aspen	FT	Zircon
317	Halfmoon Creek stock	MM-90	39 08 12	106 30 14	Lake	Mount Champion	K-Ar	Biotite
318	Hornblende quartz diorite	AS-11	39 08 10	106 49 05	Pitkin	Aspen	FT	Zircon
319	Halfmoon Creek stock	MM-12	39 08 08	106 29 36	Lake	Mt. Massive	K-Ar	Biotite
320	Quartz monzonite	AS-1	39 08 04	106 46 09	Pitkin	Aspen	FT	Apatite
321	Quartz monzonite	AS-1	39 08 04	106 46 09	Pitkin	Aspen	FT	Zircon
322	Feldspathic gneiss	4579	39 08 00	106 46 00	Pitkin	Aspen	Rb-Sr	Whole rock
323	Little Annie quartz-muscovite porphyry.	HNMP	39 07 57	106 49 30	Pitkin	Aspen	K-Ar	Muscovite
324	Feldspathic gneiss	4580a	39 07 30	106 41 00	Pitkin	New York Peak	Rb-Sr	Whole rock
325	Feldspathic gneiss	4580b	39 07 30	106 41 00	Pitkin	New York Peak	Rb-Sr	Whole rock

Age (Ma)	Analytical uncertainty	Source of date	Geologic reference	Mining district	Comment
38.5	0.6	Cunningham and others (1977)	Behre (1953)	Leadville	Big Six mine, Leadville.
64		Simmons and Hedge (1978)	Tweto and others (1978)	Leadville	
67		Simmons and Hedge (1978)	Tweto and others (1978)	Leadville	
24.6	12	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	
34	3.9	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	
35.5	4.5	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	
28.8	4.2	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Black Cloud mine 150 m from Sunday vein.
31.6	5.2	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Black Cloud mine 100 m from Sunday vein.
51.1	5.5	Bryant and Naeser (1980)	Bryant (1979)	Aspen	Date reflects uplift of Sawatch Range.
39.6	1.7	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Hydrothermal sericite: date likely indicates age of mineralization.
43.1	7.6	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Unaltered.
43.1	4.3	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Unaltered.
61.5		Linn (1963); Marvin and others (1974).	Tweto (1974)		Too young; reflects post-intrusive mineralizing event.
100	11	Moorbath and others (1967)	Tweto (1974)		Date too old.
30.3	5	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Above 504S ore body, Black Cloud mine; altered.
32	5	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Adjacent to 504S ore body, Black Cloud mine; altered.
32	5.4	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Adjacent to 504S ore body, Black Cloud mine; altered.
33.8	6.4	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Adjacent to 504S ore body, Black Cloud mine; altered.
34	5.4	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Adjacent to 504S ore body, Black Cloud mine; altered.
37.7	5.6	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Adjacent to 504S ore body, Black Cloud mine; altered.
38.3	6	Thompson and Arehart (1990)	Thompson and Arehart (1990)	Leadville	Adjacent to 504S ore body, Black Cloud mine; altered.
38.7	4	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Intensely altered.
42.1	6.8	Beaty and others (1987)	Tweto (1974)	Tennessee Pass	Intensely altered.
852	288	Bryant and others (1990)	Bryant (1979)	Aspen	Pennsylvanian rocks with Proterozoic source terrane.
63.9	2.3	Van Loenen and others (1989)	Van Loenen (1985)		Reportedly resembles Pando Porphyry.
52.8	12	Bryant and Naeser (1980)	Bryant (1979)	Aspen	Date reflects uplift of Sawatch Range.
648	186	Bryant and others (1990)	Bryant (1979)	Aspen	Pennsylvanian-Permian sedimentary rocks.
52.1	5	Bryant and others (1990)	Bryant (1979)	Aspen	Weakly altered.
52.1	4.4	Bryant and others (1990)	Bryant (1979)	Aspen	Altered; Smuggler mine.
58.6	6.1	Bryant and others (1990)	Bryant (1979)	Aspen	Altered; Smuggler mine.
32	1.1	Obradovich and others (1969)	Tweto and others (1978)		Recalculated.
53.1	4.9	Bryant and others (1990)	Bryant (1979)	Aspen	
69.8	34	Bryant and others (1990)	Bryant (1979)	Aspen	Middle Proterozoic rocks.
586	111	Bryant and others (1990)	Bryant (1979)	Aspen	Middle Proterozoic rocks.
28.7	5.3	Bryant and others (1990)	Bryant (1979)	Aspen	Middle Proterozoic rocks.
399	15	R. Van Loenen, unpub. data	Van Loenen (1985)		Date too old: excess radiogenic argon or Proterozoic xenocrysts.
22.3	9.2	Bryant and others (1990)	Bryant (1979)	Aspen	
50	7.2	Bryant and others (1990)	Bryant (1979)	Aspen	
54.4	2	Van Loenen and others (1989)	Van Loenen (1985)		Altered rock, so date likely too young.
53.4	5	Bryant and others (1990)	Bryant (1979)	Aspen	
44.3	1.6	Van Loenen and others (1989)	Van Loenen (1985)		Altered rock, so date likely too young.
31.9	15	Bryant and others (1990)	Bryant (1979)	Aspen	Middle Proterozoic rocks
451	74	Bryant and others (1990)	Bryant (1979)	Aspen	Middle Proterozoic rocks
1,520		Moorbath and others (1967)	Tweto and others (1978)		Location approximate; initial $^{87}Sr/^{86}Sr$ of Wetherill and Bickford (1965).
74	2.2	Obradovich and others (1969)	Bryant (1979)	Aspen	Recalculated; contains pyrite, so pre-ore at Aspen.
1,395	35	Moorbath and others (1967)	Tweto and others (1978)		Location approximate; initial $^{87}Sr/^{86}Sr$ of Wetherill and Bickford (1965).
1,700		Moorbath and others (1967)	Tweto and others (1978)		Location approximate; initial $^{87}Sr/^{86}Sr$ of Wetherill and Bickford (1965).

Appendix A. Summary of isotopic geochronology and related information, Leadville 1°x2° quadrangle, Colorado—Continued

Map No.	Unit name	Sample No.	Latitude (N.)	Longitude (W.)	County	7-1/2-minute quadrangle	Method	Mineral
326	Feldspathic gneiss	4581a	39 07 30	106 38 00	Pitkin	Thimble Rock	Rb-Sr	Whole rock
327	Feldspathic gneiss	4581b	39 07 30	106 38 00	Pitkin	Thimble Rock	Rb-Sr	Whole rock
328	Feldspathic gneiss	4582	39 07 30	106 34 45	Pitkin	New York Peak	Rb-Sr	Whole rock
329	Quartz latite dike	MM-01	39 07 25	106 32 55	Lake	New York Peak	K-Ar	Biotite
330	Snowmass pluton	386	39 07 03	107 02 26	Pitkin	Snowmass Mountain	K-Ar	Biotite
331	Granite (Denny Creek?)	CO-42	39 06 30	106 34 20	Pitkin	Independence Pass	Rb-Sr	Whole rock
332	Aplite porphyry	AS-10	39 06 20	106 48 01	Pitkin	Hayden Peak	FT	Zircon
333	Aplite porphyry	1045	39 06 20	106 48 01	Pitkin	Hayden Peak	K-Ar	Biotite
334	Lincoln Gulch stock	NY-5	39 05 20	106 38 29	Pitkin	Independence Pass	K-Ar	Biotite
335	Grizzly Peak Tuff	MA-1	39 05 05	106 34 58	Lake	Independence Pass	K-Ar	Biotite
336	Granite (Denny Creek?)	CO-38	39 05 00	106 17 05	Lake	Granite	Rb-Sr	Whole rock
337	Grizzly Peak Tuff	ZB-2	39 04 46	106 34 35	Lake	Independence Pass	K-Ar	Hornblende
338	Monitor rock plug	73N7	39 04 21	106 27 03	Lake	Mount Elbert	FT	Apatite
339	Twin Lakes stock	TL-F-6-16	39 04 14	106 24 11	Lake	Mount Elbert	FT	Apatite
340	Twin Lakes stock	TL-F-6-16	39 04 14	106 24 11	Lake	Mount Elbert	FT	Sphene
341	Twin Lakes stock	TL-F-6-16	39 04 14	106 24 11	Lake	Mount Elbert	FT	Zircon
342	Twin Lakes stock	4534	39 04 13	106 25 00	Lake	Mount Elbert(?)	Rb-Sr	Biotite
343	Twin Lakes stock	TL	39 04 12	106 28 25	Lake	Mount Elbert	K-Ar	Biotite
344	Twin Lakes stock	TL	39 04 12	106 28 25	Lake	Mount Elbert	Rb-Sr	Biotite
345	Twin Lakes stock	73N8	39 04 09	106 30 35	Lake	Independence Pass	FT	Apatite
346	Twin Lakes stock aplite.	73N9	39 03 56	106 23 59	Lake	Mount Elbert	FT	Apatite
347	Rhyolite porphyry	USGS(D)G-A-82	39 03 50	106 15 19	Lake	Granite	K-Ar	Whole rock
348	Grizzly Peak Tuff	AVG-1	39 03 48	106 19 16	Lake	Granite	K-Ar	Biotite
349	Treasure Mountain granite.	348	39 03 16	107 07 08	Gunnison	Snowmass Mountain	K-Ar	Biotite
350	Grand Mesa basalt	—	39 03 00	108 03 00	Mesa	Mesa Lakes	K-Ar	Whole rock
351	Rhyolite porphyry	USGS(D)JH-9-82	39 02 10	106 06 30	Park	Jones Hill	K-Ar	Biotite
352	Pine Creek stock	PC-1	39 02 00	106 41 00	Gunnison	New York Peak	K-Ar	Biotite
353	Pine Creek stock	PC-1	39 02 00	106 41 00	Gunnison	New York Peak	K-Ar	Biotite
354	Migmatite	C-39	39 01 50	106 46 07	Pitkin	Hayden Peak	FT	Apatite
355	Sawmill Stock, Grizzly Peak cauldron.	SAWM-1	39 01 39	106 36 54	Pitkin	Independence Pass	K-Ar	Biotite
356	Mount Bellview quartz monzonite.	MB-4	39 00 59	107 01 07	Gunnison	Snowmass Mountain	K-Ar	Biotite(?)
357	Whiterock pluton	WR-2	39 00 35	106 50 16	Pitkin	Hayden Peak	K-Ar	Biotite
358	Twin Lakes stock	R8-28-84-8a	39 00 18	106 33 12	Lake	Independence Pass	$^{40}Ar/^{39}Ar$	Hornblende
359	Buffalo Peaks Andesite	75-S-2	39 00 00	106 06 30	Lake	Jones Hill	FT	Zircon
360	Buffalo Peaks Andesite	75-S-2	39 00 00	106 06 30	Lake	Jones Hill	FT	Zircon
361	Badger Creek Tuff	75-S-5	39 00 00	106 04 00	Lake	Jones Hill	FT	Zircon
362	Badger Creek Tuff	75-S-5	39 00 00	106 04 00	Lake	Jones Hill	FT	Zircon

Age (Ma)	Analytical uncertainty	Source of date	Geologic reference	Mining district	Comment
1,750		Moorbath and others (1967)	Tweto and others (1978)		Location approximate; initial $^{87}Sr/^{86}Sr$ of Wetherill and Bickford (1965).
1,970		Moorbath and others (1967)	Tweto and others (1978)		Location approximate; initial $^{87}Sr/^{86}Sr$ of Wetherill and Bickford (1965).
1,670		Moorbath and others (1967)	Tweto and others (1978)		Location approximate; initial $^{87}Sr/^{86}Sr$ of Wetherill and Bickford (1965).
65.4	2.4	Van Loenen and others (1989)	Van Loenen (1985)		Reportedly resembles Pando Porphyry.
35	1.4	Obradovich and others (1969)	Mutschler (1980)		Recalculated.
1,650	35	Wetherill and Bickford (1965)	Tweto and others (1978)		Date based on isochron using several samples.
48.7	5	Bryant and others (1990)	Bryant (1979)	Aspen	Same sample as 1045 of Obradovich and others (1969).
68.7	2.3	Obradovich and others (1969)	Bryant (1979)	Hayden Peak	Recalculated; same sample as AS-10 of Bryant and others (1990).
34.8	1.1	Obradovich and others (1969)	Fridrich and others (1991)		Recalculated; resurgent stock, Grizzly Peak caldera.
33.4	1	Fridrich (1986)	Fridrich (1986)		Intracaldera fiamme.
1,650	35	Wetherill and Bickford (1965)	Tweto (1974)		Date based on isochron using several samples.
33.8	1.1	Fridrich (1986)	Fridrich (1986)		Intracaldera fiamme.
19.9	4.4	Bryant and Naeser (1980)	Tweto and others (1978)		Date reflects uplift of Sawatch Range.
20	2.9	Bryant and Naeser (1980)	Tweto and others (1978)		Date reflects Sawatch Range uplift; 18.5 Ma in Marvin and others (1974).
39.2	4.2	Marvin and others (1974)	Tweto and others (1978)		Date reflects uplift of Sawatch Range; intrusive age is 64 Ma.
44.1	5	Marvin and others (1974)	Tweto and others (1978)		Date reflects uplift of Sawatch Range; intrusive age is 64 Ma.
56	10	Moorbath and others (1967)	Tweto and others (1978)		Location approximate; 8 Ma too young.
42.7	1.2	Obradovich and others (1969)	Tweto and others (1978)		Recalculated; Shannon and others (1987) give 64 Ma $^{40}Ar/^{39}Ar$ date.
49.7	4.5	Obradovich and others (1969)	Tweto and others (1978)		Dated by C. Hedge; alpha= 1.39×10^{-11}yr.
29.9	4.2	Bryant and Naeser (1980)	Tweto and others (1978)		Date reflects uplift of Sawatch Range.
16	2.4	Bryant and Naeser (1980)	Tweto and others (1978)		Date reflects uplift of Sawatch Range.
65.3	2.4	Marvin and others (1989)	Hedlund (1985)		
33.3	1	Fridrich (1986)	Fridrich (1986)		Outflow tuff near Twin Lakes dam; not shown on Tweto and others (1978).
12.8	0.6	Obradovich and others (1969)	Mutschler (1980)		Recalculated.
10	0.5	Marvin and others (1974)	U.S. Geological Survey (1966)		Recalculated; outside of quad, but unit extends into quad.
61.4	2.2	Marvin and others (1989)	Hedlund (1985)	Granite	
35.7	1.2	Fridrich and others (1991)	Fridrich (1986)		Slightly old date; late-resurgent intrusion, Grizzly Peak caldera.
36.8	1.4	Fridrich and others (1991)	Fridrich (1986)		Slightly old date; late-resurgent intrusion, Grizzly Peak caldera.
27.9	3.9	Bryant and Naeser (1980)	Bryant (1979)	Aspen	Date reflects uplift of Sawatch Range.
32.9	1.1	Fridrich (1986)	Fridrich (1986)		Post-resurgent stock in Grizzly Peak caldera.
24.2	1.4	Lynch and others (1985); Stein (1985).	Mutschler (1980)	Mt. Bellview	Related to molybdenum prospect.
34.8	1	Obradovich and others (1969)	Bryant (1979)		Recalculated.
63.8	1.4	E.H. DeWitt, unpub. data	Shannon and others (1987)		Plateau age; hornblende tonalite, border phase of Twin Lakes pluton.
37.1	3.4	Sanders and others (1976)	Hedlund and others (1985)		Location approximate.
34	3.5	Sanders and others (1976)	Hedlund and others (1985)		Location approximate.
31.6	3.1	Sanders and others (1976)	Hedlund and others (1985)		Location approximate.
33	4	Sanders and others (1976)	Hedlund and others (1985)		Location approximate.

Appendix B. Geochronologic data listed in order of increasing age

[Method: C-14, carbon-14; FT, fission track; K-Ar, potassium-argon; Nd-Sm, neodymium-samarium; Pb-alpha, lead-alpha; Rb-Sr, rubidium-strontium; U-Th-Pb, uranium-thorium-lead]

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
32	Basalt--Dotsero	C-14	Wood	4,150 yr	300 yr
5	Basalt, nepheline-normative	K-Ar	Whole rock	0.66	0.2
251	Basalt, nepheline-normative	K-Ar	Whole rock	1.28	0.2
252	Basalt, nepheline-normative	K-Ar	Whole rock	2.03	0.3
160	Basalt	K-Ar	Whole rock	8.07	0.4
142	Basalt	K-Ar	Whole rock	8.91	0.4
131	Basalt	K-Ar	Whole rock	9.01	0.4
20	Basaltic andesite	K-Ar	Whole rock	9.9	0.5
350	Grand Mesa basalt	K-Ar	Whole rock	10	0.5
59	Basalt	K-Ar	Whole rock	10.4	0.5
3	Basaltic andesite	K-Ar	Whole rock	10.6	0.5
70	Basalt	K-Ar	Whole rock	11.4	1
1	Rhyolite ash fall	FT	Zircon	12.8	2.3
349	Treasure Mountain granite	K-Ar	Biotite	12.8	0.6
21	Basaltic andesite	K-Ar	Whole rock	13.5	0.5
6	Basaltic andesite	K-Ar	Whole rock	13.8	0.5
346	Twin Lakes stock aplite	FT	Apatite	16	2.4
8	Basalt	K-Ar	Whole rock	18	
200	Climax--Seriate granite stock	FT	Zircon	18.2	0.9
24	Basalt	K-Ar	Whole rock	19	0.8
338	Monitor rock plug	FT	Apatite	19.9	4.4
339	Twin Lakes stock	FT	Apatite	20	2.9
9	Basalt	K-Ar	Whole rock	20.4	
25	Basalt	K-Ar	Whole rock	20.4	0.8
26	Basalt	K-Ar	Whole rock	20.6	0.8
10	Basalt	K-Ar	Whole rock	21.1	
27	Basalt	K-Ar	Whole rock	21.2	0.8
28	Basalt	K-Ar	Whole rock	21.2	1
11	Basalt	K-Ar	Whole rock	21.6	
29	Basalt	K-Ar	Whole rock	22	1
315	Quartz porphyry	FT	Apatite	22.3	9.2
12	Basalt	K-Ar	Whole rock	22.5	
13	Basalt	K-Ar	Whole rock	22.6	
7	Basalt	K-Ar	Whole rock	22.7	1
30	Basalt	K-Ar	Whole rock	22.8	1
14	Basalt	K-Ar	Whole rock	22.9	
192	Climax--"Central Mass"	FT	Zircon	23.3	1.1
2	Basalt	K-Ar	Whole rock	23.6	1
15	Basalt	K-Ar	Whole rock	23.6	
16	Basalt	K-Ar	Whole rock	23.6	
4	Basalt	K-Ar	Whole rock	23.8	1
356	Mount Bellview quartz monzonite	K-Ar	Biotite(?)	24.2	1.4
199	Climax--Seriate granite stock	FT	Zircon	24.4	4.9
17	Basalt	K-Ar	Whole rock	24.6	
282	Johnson Gulch Porphyry	FT	Apatite	24.6	12
18	Basalt	K-Ar	Whole rock	24.9	
194	Climax--late barren stage sericite	K-Ar	Sericite	25.3	0.3
195	Climax--late rhyolite porphyry	FT	Zircon	25.5	1.2
78	Cross Creek Granite	FT	Apatite	25.5	5.7
19	Basalt	K-Ar	Whole rock	25.7	
193	Climax--biotite rhyolite porphyry	FT	Zircon	26.1	1.2
237	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg. 3)	26.7	4
236	Buckskin biotite granodiorite dike	FT	Zircon	27.6	3
190	Chalk Mountain Rhyolite	K-Ar	Biotite	27.7	1.9
354	Migmatite	FT	Apatite	27.9	3.9
52	Pando Porphyry	FT	Apatite	28.7	22
313	Quartz monzonite	FT	Apatite	28.7	5.3
285	Johnson Gulch Porphyry	FT	Zircon	28.8	4.2
60	Cross Creek Granite	FT	Apatite	29.2	18
76	Cross Creek Granite	FT	Apatite	29.7	4.9
186	Lincoln Porphyry	K-Ar	Biotite	29.8	2
23	Green Mountain trachyte dike	FT	Zircon	29.9	2.4
22	Latite porphyry	FT	Zircon	29.9	2.4
345	Twin Lakes stock	FT	Apatite	29.9	4.2
210	Grizzly Peak Tuff (outflow)	FT	Zircon	30.1	3
211	Grizzly Peak Tuff (outflow)	FT	Zircon	30.2	0.9
205	Climax porphyritic granite	K-Ar	Muscovite	30.3	1
293	Johnson Gulch Porphyry	FT	Zircon	30.3	5
201	Climax--upper ore body sericite	K-Ar	Sericite	30.6	0.4
202	Lincoln Porphyry	K-Ar	Biotite	30.8	2
361	Badger Creek Tuff	FT	Zircon	31.6	3.1
286	Johnson Gulch Porphyry	FT	Zircon	31.6	5.2
320	Quartz monzonite	FT	Apatite	31.9	15

Appendix B. Geochronologic data listed in order of increasing age—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
294	Johnson Gulch Porphyry	FT	Zircon	32	5
295	Johnson Gulch Porphyry	FT	Zircon	32	5.4
309	Snowmass Creek sill	K-Ar	Biotite	32	1.1
63	Cross Creek Granite	FT	Apatite	32.3	4.9
73	Minturn Formation	FT	Apatite	32.9	4.5
355	Sawmill Stock, Grizzly Peak cauldron	K-Ar	Biotite	32.9	1.1
362	Badger Creek Tuff	FT	Zircon	33	4
198	Climax–Rhyolite porphyry	FT	Zircon	33.2	2.1
348	Grizzly Peak Tuff	K-Ar	Biotite	33.3	1
335	Grizzly Peak Tuff	K-Ar	Biotite	33.4	1
337	Grizzly Peak Tuff	K-Ar	Hornblende	33.8	1.1
296	Johnson Gulch Porphyry	FT	Zircon	33.8	6.4
360	Buffalo Peaks Andesite	FT	Zircon	34	3.5
283	Johnson Gulch Porphyry	FT	Zircon	34	3.9
297	Johnson Gulch Porphyry	FT	Zircon	34	5.4
261	Mount Sopris stock	FT	Zircon	34.2	3.7
262	Mount Sopris stock	K-Ar	Biotite	34.2	0.8
56	Hydrothermal apatite	FT	Apatite	34.5	4.4
334	Lincoln Gulch stock	K-Ar	Biotite	34.8	1.1
357	Whiterock pluton	K-Ar	Biotite	34.8	1
220	Buckskin porphyritic rhyolite-A dike	FT	Zircon	34.9	4
183	Lincoln Porphyry	FT	Apatite	34.9	7.1
330	Snowmass pluton	K-Ar	Biotite	35	1.4
238	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg. 7)	35.4	3.3
149	Biotite rhyolite-B porphyry	FT	Zircon	35.5	3.2
49	Cross Creek Granite	FT	Apatite	35.5	15
284	Johnson Gulch Porphyry	FT	Zircon	35.5	4.5
260	Turquoise Lake porphyry	K-Ar	Sericite	35.6	1.4
352	Pine Creek stock	K-Ar	Biotite	35.7	1.2
129	Humbug stock	K-Ar	Biotite	35.8	2
128	Humbug stock	K-Ar	Biotite	35.9	1.4
257	Timberline Lake latite breccia	K-Ar	Sericite	35.9	1.2
124	Tucker Mountain rhyolite porphyry	K-Ar	Sanidine(?)	36.1	1.4
212	Grizzly Peak Tuff (outflow)	K-Ar	Biotite	36.3	0.9
132	Lincoln Porphyry	FT	Apatite	36.7	3.9
114	Tucker Mountain quartz monzonite	FT	Apatite	36.7	3.8
353	Pine Creek stock	K-Ar	Biotite	36.8	1.4
359	Buffalo Peaks Andesite	FT	Zircon	37.1	3.4
115	Elk Mountain Porphyry	K-Ar	Biotite	37.6	1.6
158	Elk Mountain Porphyry	FT	Zircon	37.6	3.7
298	Johnson Gulch Porphyry	FT	Zircon	37.7	5.6
57	Cross Creek Granite	FT	Apatite	38.2	10
203	Lincoln Porphyry	FT	Zircon	38.2	3.5
299	Johnson Gulch Porphyry	FT	Zircon	38.3	6
122	Quartz latite porphyry	FT	Zircon	38.3	4.4
279	Rhyolite porphyry (Eureka pipe)	K-Ar	Sanidine	38.5	0.6
300	Lincoln Porphyry	FT	Zircon	38.7	4
64	Minturn Formation	FT	Apatite	38.9	15
340	Twin Lakes stock	FT	Sphene	39.2	4.2
207	Lincoln Porphyry	FT	Zircon	39.5	4
123	Tucker Mountain rhyolite porphyry	FT	Zircon	39.5	4.5
80	Cross Creek Granite	FT	Apatite	39.6	11
288	Johnson Gulch Porphyry	K-Ar	Sericite	39.6	1.7
88	Cross Creek Granite	FT	Apatite	39.8	18
170	Lincoln Porphyry	FT	Zircon	39.9	3.6
71	Cross Creek Granite	FT	Apatite	40.1	24
140	Lincoln Porphyry	FT	Zircon	40.1	3.9
150	Biotite rhyolite-B porphyry	K-Ar	Sanidine	40.2	2
62	Pando Porphyry	FT	Zircon	40.4	4.6
156	Quail Porphyry	FT	Zircon	40.4	4.5
171	Lincoln Porphyry	FT	Apatite	40.7	7.5
120	Lincoln Porphyry	K-Ar	Biotite	41	2.1
93	Pando Porphyry	FT	Apatite	41.1	32
95	Cross Creek Granite	FT	Apatite	41.5	11
126	Humbug stock	K-Ar	Biotite	41.5	1
133	Lincoln Porphyry	FT	Zircon	41.5	3.7
152	Quail Porphyry	FT	Apatite	41.6	10.4
116	Tucker Mountain quartz monzonite	FT	Zircon	41.8	3
164	Elk Mountain Porphyry	FT	Apatite	41.9	9.5
213	Lincoln Porphyry	FT	Apatite	42	7.6
221	Granodiorite stock	K-Ar	Biotite	42.1	1.2
264	Johnson Gulch Porphyry	K-Ar	Biotite	42.1	
184	Lincoln Porphyry	FT	Zircon	42.1	4.3
301	Lincoln Porphyry	FT	Apatite	42.1	6.8
125	Humbug stock	K-Ar	Biotite	42.4	1
343	Twin Lakes stock	K-Ar	Biotite	42.7	1.2

Appendix B. Geochronologic data listed in order of increasing age—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
45	Pando Porphyry	FT	Zircon	42.9	4.8
77	Fulford stock	FT	Apatite	43.1	10
289	Johnson Gulch Porphyry	FT	Apatite	43.1	7.6
290	Johnson Gulch Porphyry	FT	Zircon	43.1	4.3
214	Lincoln Porphyry	FT	Zircon	43.3	4.2
151	Biotite rhyolite-B porphyry	K-Ar	Biotite	43.5	3
79	Cross Creek Granite	FT	Apatite	43.5	14
172	Lincoln Porphyry	FT	Sphene	43.7	6.6
239	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg. 4)	43.9	5.6
263	Sacramento Porphyry	FT	Zircon	43.9	4.3
121	Tucker Mountain quartz monzonite	K-Ar	Biotite	43.9	2
34	Swan Mtn. quartz monzonite sill	Rb-Sr	Whole rock	44	
33	Swan Mtn. quartz monzonite sill	K-Ar	Biotite	44.1	1.6
341	Twin Lakes stock	FT	Zircon	44.1	5
98	Cross Creek Granite	FT	Apatite	44.2	10
229	Syenodiorite	FT	Apatite	44.2	13
319	Halfmoon Creek stock	K-Ar	Biotite	44.3	1.6
153	Quail Porphyry	FT	Zircon	44.4	5.3
47	Pando Porphyry	FT	Zircon	44.5	5.2
127	Humbug stock	K-Ar	Biotite	44.7	2.1
39	Pando Porphyry	FT	Zircon	45.2	5.1
232	Sacramento Porphyry	FT	Apatite	45.2	19
154	Quail Porphyry	FT	Apatite	45.3	8.3
53	Pando Porphyry	FT	Zircon	45.9	4.3
54	Pando Porphyry	FT	Zircon	45.9	5.8
157	Quail Porphyry	FT	Apatite	46.1	8.2
208	West Tennessee Creek stock	FT	Apatite	46.4	9.8
90	Pando Porphyry	FT	Zircon	46.6	5.8
103	Unnamed diorite	FT	Apatite	46.7	19
272	Evans Gulch Porphyry	FT	Zircon	47	3.9
130	Humbug stock	K-Ar	Biotite	48	2.2
38	Pando Porphyry	FT	Zircon	48	5.6
55	Pando Porphyry	FT	Zircon	48.2	7
68	Cross Creek Granite	FT	Apatite	48.3	11
241	Lincoln Porphyry	FT	Apatite	48.3	17
230	Syenodiorite	FT	Zircon	48.4	4.9
141	Lincoln Porphyry	FT	Apatite	48.6	6.6
109	Pando Porphyry	FT	Apatite	48.6	26.3
332	Aplite porphyry	FT	Zircon	48.7	5
215	Lincoln Porphyry	FT	Sphene	49.3	8
48	Pando Porphyry	FT	Zircon	49.7	5.6
344	Twin Lakes stock	Rb-Sr	Biotite	49.7	4.5
316	Quartz porphyry	FT	Zircon	50	7.2
101	Cross Creek Granite	FT	Apatite	50.8	24
165	Elk Mountain Porphyry	FT	Zircon	50.9	5.2
155	Quail Porphyry	FT	Zircon	51	5.1
287	Quartz monzonite	FT	Apatite	51.1	5.5
137	West Cross Creek diorite	FT	Apatite	51.1	11
185	Lincoln Porphyry	K-Ar	Biotite	51.3	5
159	Elk Mountain Porphyry	FT	Apatite	51.5	12.3
162	Treasure Vault stock	FT	Apatite	52	15.7
306	Aplite porphyry	FT	Zircon	52.1	5
307	Aplite porphyry	FT	Zircon	52.1	4.4
83	Pando Porphyry	FT	Zircon	52.5	5
304	Granodiorite	FT	Apatite	52.8	12
181	Eagle River Porphyry	FT	Zircon	52.9	6
91	Pando Porphyry	FT	Zircon	53	7.9
310	Aplite porphyry	FT	Zircon	53.1	4.9
110	Pando Porphyry	FT	Zircon	53.2	6.2
318	Hornblende quartz diorite	FT	Zircon	53.4	5
51	Pando Porphyry	FT	Zircon	53.4	6
233	Sacramento Porphyry	FT	Zircon	53.6	6
317	Halfmoon Creek stock	K-Ar	Biotite	54.4	2
182	Eagle River Porphyry	FT	Apatite	54.5	17
36	Pando Porphyry	FT	Zircon	54.9	6.2
82	Pando Porphyry	FT	Zircon	55.2	6.6
253	Pando Porphyry	FT	Zircon	55.5	5.6
240	Biotite granodiorite stock	K-Ar	Biotite	55.9	2.5
111	Cross Creek Granite	FT	Apatite	55.9	20
342	Twin Lakes stock	Rb-Sr	Biotite	56	10
204	Lincoln Porphyry	FT	Apatite	56.4	11.1
46	Pando Porphyry	FT	Zircon	56.4	8.4
85	Cross Creek Granite	FT	Apatite	58	21
37	Pando Porphyry	FT	Zircon	58.1	6.8
308	Aplite porphyry	FT	Zircon	58.6	6.1
100	Pando Porphyry	FT	Zircon	58.9	7

Appendix B. Geochronologic data listed in order of increasing age—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
138	West Cross Creek stock	FT	Zircon	59.3	6.2
112	East Lake Creek stock	FT	Zircon	59.7	7.5
94	Pando Porphyry	FT	Zircon	60.1	7.8
250	Pando Porphyry	FT	Zircon	60.6	6.8
256	Pando Porphyry	FT	Zircon	61.1	6.3
351	Rhyolite porphyry	K-Ar	Biotite	61.4	2.2
291	Pando Porphyry	K-Ar	Sericite	61.5	
139	West Cross Creek stock	K-Ar	Biotite	61.8	1.4
84	Fulford stock	K-Ar	Biotite	62.2	1.5
119	Quartz latite dike	K-Ar	Biotite	62.2	1.7
234	Buckskin Gulch granodiorite	K-Ar	Biotite	62.4	1.9
40	Pando Porphyry	FT	Apatite	63	40
136	Quartz latite dike	K-Ar	Sericite	63	1.5
358	Twin Lakes stock	40Ar/39Ar	Hornblende	63.8	1.4
303	Quartz latite dike	K-Ar	Biotite	63.9	2.3
280	Evans Gulch Porphyry	Rb-Sr	Whole rock	64	
161	Treasure Vault stock	K-Ar	Biotite	64	2.3
177	Granodiorite	K-Ar	Biotite	64.6	3
231	Syenodiorite	FT	Sphene	64.7	18
113	East Lake Creek stock	FT	Sphene	65.3	5.5
87	Fulford stock	FT	Zircon	65.3	6
347	Rhyolite porphyry	K-Ar	Whole rock	65.3	2.4
329	Quartz latite dike	K-Ar	Biotite	65.4	2.4
178	Granodiorite	K-Ar	Biotite	65.6	3
216	Lincoln Porphyry	K-Ar	Biotite	65.6	
117	Migmatite	FT	Apatite	65.9	23
246	Lincoln Porphyry	K-Ar	Biotite	66.3	1.9
209	West Tennessee Creek stock	K-Ar	Biotite	66.4	2.2
228	Buckskin Gulch leucogranite	K-Ar	Biotite	66.7	1.6
281	Johnson Gulch Porphyry	Rb-Sr	Whole rock	67	
206	Lincoln Porphyry	Rb-Sr	Whole rock	67	
218	Pando Porphyry	FT	Zircon	67.7	7.7
333	Aplite porphyry	K-Ar	Biotite	68.7	2.3
92	Pando Porphyry	FT	Apatite	69	34
163	Treasure Vault stock	FT	Zircon	69.4	7.2
311	Quartz monzonite	FT	Apatite	69.8	34
243	Buckskin Gulch dacite	K-Ar	Biotite	69.9	1.7
179	Missouri Creek granodiorite	K-Ar	Biotite	70.8	3
244	Buckskin Gulch melagranodiorite	K-Ar	Biotite	71.2	1.7
245	Quartz monzonite stock	K-Ar	Biotite	71.4	2.4
176	Missouri Creek stock	K-Ar	Biotite	71.8	
254	Pando Porphyry	K-Ar	Biotite	71.8	
219	Pando Porphyry	FT	Apatite	72.7	23.9
191	Climax sericite	Rb-Sr	Sericite	73	8
242	Lincoln Porphyry	FT	Zircon	73.6	8.2
323	Little Annie quartz-muscovite porphyry	K-Ar	Muscovite	74	2.2
168	Climax mine	Rb-Sr	Sericite	74.8	8
196	Climax–Precambrian granite	K-Ar	Biotite	74.9	2.3
173	Paragneiss	K-Ar	Biotite	92.3	5
197	Climax–Precambrian granite	K-Ar	Biotite	96.4	2.9
292	Pando Porphyry	Rb-Sr	Whole rock	100	11
265	Johnson Gulch Porphyry	Pb-alpha	Zircon	120	20
271	Johnson Gulch Porphyry	Pb-alpha	Zircon	130	20
66	Minturn Formation	FT	Apatite	213	32
35	Minturn Formation	FT	Zircon	231	31
148	Mylonite	K-Ar	Whole rock	332	16
314	Quartz latite dike	K-Ar	Biotite	399	15
321	Quartz monzonite	FT	Zircon	451	74
169	Gneiss	K-Ar	Biotite	483	24
58	Cross Creek Granite	FT	Zircon	486	64
81	Cross Creek Granite	FT	Zircon	500	96
217	Lincoln Porphyry	Pb-alpha	Zircon	530	60
65	Minturn Formation	FT	Zircon	542	95
75	Minturn Formation	FT	Zircon	550	71
74	Minturn Formation	FT	Zircon	562	84
312	Quartz monzonite	FT	Zircon	586	111
305	Maroon Formation	FT	Zircon	648	186
61	Cross Creek Granite	FT	Zircon	671	170
104	Unnamed diorite	FT	Zircon	758	11
69	Cross Creek Granite	FT	Zircon	766	180
96	Cross Creek Granite	FT	Zircon	771	170
302	Gothic Formation	FT	Zircon	852	288
99	Cross Creek Granite	FT	Zircon	877	200
89	Cross Creek Granite	FT	Zircon	904	250
67	Minturn Formation	FT	Zircon	994	150
43	Cross Creek Granite	Pb-alpha	Zircon	1,065	20

Appendix B. Geochronologic data listed in order of increasing age—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
118	Silver Plume Granite	K-Ar	Biotite	1,150	30
188	Paragneiss	Pb-alpha	Zircon	1,170	13
143	Granite of Holy Cross City	K-Ar	Biotite	1,184	59
145	Migmatite	K-Ar	Biotite	1,209	60
222	St. Kevin Granite	K-Ar	Biotite	1,209	60
268	St. Kevin Granite	K-Ar	Biotite	1,210	61
274	St. Kevin Granite	K-Ar	Biotite	1,239	62
258	Paragneiss	K-Ar	Biotite	1,240	62
166	Hornblendite	K-Ar	Biotite	1,249	62
275	St. Kevin Granite	Rb-Sr	Biotite	1,250	63
223	St. Kevin Granite	Rb-Sr	Biotite	1,260	63
134	Paragneiss	K-Ar	Biotite	1,264	63
106	Migmatite	Pb-alpha	Zircon	1,280	14
224	St. Kevin Granite	Rb-Sr	Muscovite	1,290	65
146	Migmatite	K-Ar	Muscovite	1,298	65
41	Cross Creek Granite	Pb-alpha	Zircon	1,300	16
247	St. Kevin Granite	K-Ar	Biotite	1,309	65
276	St. Kevin Granite	Rb-Sr	K feldspar	1,310	13
187	Metalamprophyre	K-Ar	Biotite	1,328	66
44	Cross Creek Granite	K-Ar	Biotite	1,343	67
180	Pegmatite	K-Ar	Muscovite	1,343	67
189	Paragneiss	K-Ar	Biotite	1,358	68
225	St. Kevin Granite	K-Ar	Muscovite	1,358	68
248	St. Kevin Granite	Pb-alpha	Zircon	1,362	15
147	Migmatite	Pb-alpha	Zircon	1,365	15
107	Migmatite	K-Ar	Biotite	1,368	68
175	Pegmatite	K-Ar	Muscovite	1,368	68
324	Feldspathic gneiss	Rb-Sr	Whole rock	1,395	35
174	Paragneiss	Pb-alpha	Zircon	1,405	16
259	St. Kevin Granite	U-Th-Pb	Zircon	1,411	40
266	St. Kevin Granite	U-Th-Pb	Zircon	1,411	40
273	St. Kevin Granite	U-Th-Pb	Zircon	1,411	40
226	St. Kevin Granite	Rb-Sr	K feldspar	1,430	13
255	Treasurevault stock	K-Ar	Biotite(?)	1,430	45
227	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
235	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
249	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
269	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
270	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
277	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
278	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
42	Cross Creek Granite	K-Ar	Biotite	1,442	72
135	Paragneiss	Pb-alpha	Zircon	1,495	16
267	St. Kevin Granite	Pb-alpha	Zircon	1,505	17
322	Feldspathic gneiss	Rb-Sr	Whole rock	1,520	
144	Granite of Holy Cross City	Pb-alpha	Zircon	1,630	18
108	Cross Creek Granite dike	Rb-Sr	Whole rock	1,650	9
331	Granite (Denny Creek?)	Rb-Sr	Whole rock	1,650	35
336	Granite (Denny Creek?)	Rb-Sr	Whole rock	1,650	35
105	Granite gneiss	Rb-Sr	Whole rock	1,650	35
328	Feldspathic gneiss	Rb-Sr	Whole rock	1,670	
325	Feldspathic gneiss	Rb-Sr	Whole rock	1,700	
97	Cross Creek Granite	Rb-Sr	Whole rock	1,710	
326	Feldspathic gneiss	Rb-Sr	Whole rock	1,750	
31	Felsic gneiss/amphibolite	Nd-Sm	Whole rock	1,800	90
327	Feldspathic gneiss	Rb-Sr	Whole rock	1,970	
167	Hornblendite	K-Ar	Hornblende	2,018	10
50	Cross Creek Granite	FT	Zircon	Proterozoic	
72	Cross Creek Granite	FT	Zircon	Proterozoic	
86	Cross Creek Granite	FT	Zircon	Proterozoic	
102	Cross Creek Granite	FT	Zircon	Proterozoic	

Appendix C. Geochronologic data listed by unit name

[Method: C-14, carbon-14; FT, fission track; K-Ar, potassium-argon; Nd-Sm, neodymium-samarium; Pb-alpha, lead-alpha; Rb-Sr, rubidium-strontium; U-Th-Pb, uranium-thorium-lead]

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
332	Aplite porphyry	FT	Zircon	48.7	5
306	Aplite porphyry	FT	Zircon	52.1	5
307	Aplite porphyry	FT	Zircon	52.1	4.4
310	Aplite porphyry	FT	Zircon	53.1	4.9
308	Aplite porphyry	FT	Zircon	58.6	6.1
333	Aplite porphyry	K-Ar	Biotite	68.7	2.3
361	Badger Creek Tuff	FT	Zircon	31.6	3.1
362	Badger Creek Tuff	FT	Zircon	33	4
32	Basalt–Dotsero	C-14	Wood	4,150 yr	300 yr
160	Basalt	K-Ar	Whole rock	8.07	0.4
142	Basalt	K-Ar	Whole rock	8.91	0.4
131	Basalt	K-Ar	Whole rock	9.01	0.4
59	Basalt	K-Ar	Whole rock	10.4	0.5
70	Basalt	K-Ar	Whole rock	11.4	1
8	Basalt	K-Ar	Whole rock	18	
24	Basalt	K-Ar	Whole rock	19	0.8
9	Basalt	K-Ar	Whole rock	20.4	
25	Basalt	K-Ar	Whole rock	20.4	0.8
26	Basalt	K-Ar	Whole rock	20.6	0.8
10	Basalt	K-Ar	Whole rock	21.1	
27	Basalt	K-Ar	Whole rock	21.2	0.8
28	Basalt	K-Ar	Whole rock	21.2	1
11	Basalt	K-Ar	Whole rock	21.6	
29	Basalt	K-Ar	Whole rock	22	1
12	Basalt	K-Ar	Whole rock	22.5	
13	Basalt	K-Ar	Whole rock	22.6	
7	Basalt	K-Ar	Whole rock	22.7	1
30	Basalt	K-Ar	Whole rock	22.8	1
14	Basalt	K-Ar	Whole rock	22.9	
2	Basalt	K-Ar	Whole rock	23.6	1
15	Basalt	K-Ar	Whole rock	23.6	
16	Basalt	K-Ar	Whole rock	23.6	
4	Basalt	K-Ar	Whole rock	23.8	1
17	Basalt	K-Ar	Whole rock	24.6	
18	Basalt	K-Ar	Whole rock	24.9	
19	Basalt	K-Ar	Whole rock	25.7	
5	Basalt, nepheline-normative	K-Ar	Whole rock	0.66	0.2
251	Basalt, nepheline-normative	K-Ar	Whole rock	1.28	0.2
252	Basalt, nepheline-normative	K-Ar	Whole rock	2.03	0.3
20	Basaltic andesite	K-Ar	Whole rock	9.9	0.5
3	Basaltic andesite	K-Ar	Whole rock	10.6	0.5
21	Basaltic andesite	K-Ar	Whole rock	13.5	0.5
6	Basaltic andesite	K-Ar	Whole rock	13.8	0.5
240	Biotite granodiorite stock	K-Ar	Biotite	55.9	2.5
149	Biotite rhyolite-B porphyry	FT	Zircon	35.5	3.2
150	Biotite rhyolite-B porphyry	K-Ar	Sanidine	40.2	2
151	Biotite rhyolite-B porphyry	K-Ar	Biotite	43.5	3
236	Buckskin biotite granodiorite dike	FT	Zircon	27.6	3
243	Buckskin Gulch dacite	K-Ar	Biotite	69.9	1.7
234	Buckskin Gulch granodiorite	K-Ar	Biotite	62.4	1.9
228	Buckskin Gulch leucogranite	K-Ar	Biotite	66.7	1.6
244	Buckskin Gulch melagranodiorite	K-Ar	Biotite	71.2	1.7
220	Buckskin porphyritic rhyolite-A dike	FT	Zircon	34.9	4
237	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg. 3)	26.7	4
238	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg. 7)	35.4	3.3
239	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg. 4)	43.9	5.6
360	Buffalo Peaks Andesite	FT	Zircon	34	3.5
359	Buffalo Peaks Andesite	FT	Zircon	37.1	3.4
190	Chalk Mountain Rhyolite	K-Ar	Biotite	27.7	1.9
168	Climax mine	Rb-Sr	Sericite	74.8	8
205	Climax porphyritic granite	K-Ar	Muscovite	30.3	1
191	Climax sericite	Rb-Sr	Sericite	73	8
192	Climax–"Central Mass"	FT	Zircon	23.3	1.1
193	Climax–biotite rhyolite porphyry	FT	Zircon	26.1	1.2
194	Climax–late barren stage sericite	K-Ar	Sericite	25.3	0.3
195	Climax–late rhyolite porphyry	FT	Zircon	25.5	1.2
196	Climax–Precambrian granite	K-Ar	Biotite	74.9	2.3
197	Climax–Precambrian granite	K-Ar	Biotite	96.4	2.9
198	Climax–Rhyolite porphyry	FT	Zircon	33.2	2.1
200	Climax–Seriate granite stock	FT	Zircon	18.2	0.9
199	Climax–Seriate granite stock	FT	Zircon	24.4	4.9
201	Climax–upper ore body sericite	K-Ar	Sericite	30.6	0.4
78	Cross Creek Granite	FT	Apatite	25.5	5.7

Appendix C. Geochronologic data listed by unit name—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
60	Cross Creek Granite	FT	Apatite	29.2	18
76	Cross Creek Granite	FT	Apatite	29.7	4.9
63	Cross Creek Granite	FT	Apatite	32.3	4.9
49	Cross Creek Granite	FT	Apatite	35.5	15
57	Cross Creek Granite	FT	Apatite	38.2	10
80	Cross Creek Granite	FT	Apatite	39.6	11
88	Cross Creek Granite	FT	Apatite	39.8	18
71	Cross Creek Granite	FT	Apatite	40.1	24
95	Cross Creek Granite	FT	Apatite	41.5	11
79	Cross Creek Granite	FT	Apatite	43.5	14
98	Cross Creek Granite	FT	Apatite	44.2	10
68	Cross Creek Granite	FT	Apatite	48.3	11
101	Cross Creek Granite	FT	Apatite	50.8	24
111	Cross Creek Granite	FT	Apatite	55.9	20
85	Cross Creek Granite	FT	Apatite	58	21
58	Cross Creek Granite	FT	Zircon	486	64
81	Cross Creek Granite	FT	Zircon	500	96
61	Cross Creek Granite	FT	Zircon	671	170
69	Cross Creek Granite	FT	Zircon	766	180
96	Cross Creek Granite	FT	Zircon	771	170
99	Cross Creek Granite	FT	Zircon	877	200
89	Cross Creek Granite	FT	Zircon	904	250
43	Cross Creek Granite	Pb-alpha	Zircon	1,065	20
41	Cross Creek Granite	Pb-alpha	Zircon	1,300	16
44	Cross Creek Granite	K-Ar	Biotite	1,343	67
42	Cross Creek Granite	K-Ar	Biotite	1,442	72
97	Cross Creek Granite	Rb-Sr	Whole rock	1,710	
50	Cross Creek Granite	FT	Zircon	Proterozoic	
72	Cross Creek Granite	FT	Zircon	Proterozoic	
86	Cross Creek Granite	FT	Zircon	Proterozoic	
102	Cross Creek Granite	FT	Zircon	Proterozoic	
108	Cross Creek Granite dike	Rb-Sr	Whole rock	1,650	9
181	Eagle River Porphyry	FT	Zircon	52.9	6
182	Eagle River Porphyry	FT	Apatite	54.5	17
112	East Lake Creek stock	FT	Zircon	59.7	7.5
113	East Lake Creek stock	FT	Sphene	65.3	5.5
115	Elk Mountain Porphyry	K-Ar	Biotite	37.6	1.6
158	Elk Mountain Porphyry	FT	Zircon	37.6	3.7
164	Elk Mountain Porphyry	FT	Apatite	41.9	9.5
165	Elk Mountain Porphyry	FT	Zircon	50.9	5.2
159	Elk Mountain Porphyry	FT	Apatite	51.5	12.3
272	Evans Gulch Porphyry	FT	Zircon	47	3.9
280	Evans Gulch Porphyry	Rb-Sr	Whole rock	64	
324	Feldspathic gneiss	Rb-Sr	Whole rock	1,395	35
322	Feldspathic gneiss	Rb-Sr	Whole rock	1,520	
328	Feldspathic gneiss	Rb-Sr	Whole rock	1,670	
325	Feldspathic gneiss	Rb-Sr	Whole rock	1,700	
326	Feldspathic gneiss	Rb-Sr	Whole rock	1,750	
327	Feldspathic gneiss	Rb-Sr	Whole rock	1,970	
31	Felsic gneiss/amphibolite	Nd-Sm	Whole rock	1,800	90
77	Fulford stock	FT	Apatite	43.1	10
84	Fulford stock	K-Ar	Biotite	62.2	1.5
87	Fulford stock	FT	Zircon	65.3	6
169	Gneiss	K-Ar	Biotite	483	24
302	Gothic Formation	FT	Zircon	852	288
350	Grand Mesa basalt	K-Ar	Whole rock	10	0.5
331	Granite (Denny Creek?)	Rb-Sr	Whole rock	1,650	35
336	Granite (Denny Creek?)	Rb-Sr	Whole rock	1,650	35
105	Granite gneiss	Rb-Sr	Whole rock	1,650	35
143	Granite of Holy Cross City	K-Ar	Biotite	1,184	59
144	Granite of Holy Cross City	Pb-alpha	Zircon	1,630	18
304	Granodiorite	FT	Apatite	52.8	12
177	Granodiorite	K-Ar	Biotite	64.6	3
178	Granodiorite	K-Ar	Biotite	65.6	3
221	Granodiorite stock	K-Ar	Biotite	42.1	1.2
23	Green Mountain trachyte dike	FT	Zircon	29.9	2.4
348	Grizzly Peak Tuff	K-Ar	Biotite	33.3	1
335	Grizzly Peak Tuff	K-Ar	Biotite	33.4	1
337	Grizzly Peak Tuff	K-Ar	Hornblende	33.8	1.1
210	Grizzly Peak Tuff (outflow)	FT	Zircon	30.1	3
211	Grizzly Peak Tuff (outflow)	FT	Zircon	30.2	0.9
212	Grizzly Peak Tuff (outflow)	K-Ar	Biotite	36.3	0.9
319	Halfmoon Creek stock	K-Ar	Biotite	44.3	1.6
317	Halfmoon Creek stock	K-Ar	Biotite	54.4	2
318	Hornblende quartz diorite	FT	Zircon	53.4	5
166	Hornblendite	K-Ar	Biotite	1,249	62

Appendix C. Geochronologic data listed by unit name—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
167	Hornblendite	K-Ar	Hornblende	2,018	10
129	Humbug stock	K-Ar	Biotite	35.8	2
128	Humbug stock	K-Ar	Biotite	35.9	1.4
126	Humbug stock	K-Ar	Biotite	41.5	1
125	Humbug stock	K-Ar	Biotite	42.4	1
127	Humbug stock	K-Ar	Biotite	44.7	2.1
130	Humbug stock	K-Ar	Biotite	48	2.2
56	Hydrothermal apatite	FT	Apatite	34.5	4.4
282	Johnson Gulch Porphyry	FT	Apatite	24.6	12
285	Johnson Gulch Porphyry	FT	Zircon	28.8	4.2
293	Johnson Gulch Porphyry	FT	Zircon	30.3	5
286	Johnson Gulch Porphyry	FT	Zircon	31.6	5.2
294	Johnson Gulch Porphyry	FT	Zircon	32	5
295	Johnson Gulch Porphyry	FT	Zircon	32	5.4
296	Johnson Gulch Porphyry	FT	Zircon	33.8	6.4
283	Johnson Gulch Porphyry	FT	Zircon	34	3.9
297	Johnson Gulch Porphyry	FT	Zircon	34	5.4
284	Johnson Gulch Porphyry	FT	Zircon	35.5	4.5
298	Johnson Gulch Porphyry	FT	Zircon	37.7	5.6
299	Johnson Gulch Porphyry	FT	Zircon	38.3	6
288	Johnson Gulch Porphyry	K-Ar	Sericite	39.6	1.7
264	Johnson Gulch Porphyry	K-Ar	Biotite	42.1	
289	Johnson Gulch Porphyry	FT	Apatite	43.1	7.6
290	Johnson Gulch Porphyry	FT	Zircon	43.1	4.3
281	Johnson Gulch Porphyry	Rb-Sr	Whole rock	67	
265	Johnson Gulch Porphyry	Pb-alpha	Zircon	120	20
271	Johnson Gulch Porphyry	Pb-alpha	Zircon	130	20
22	Latite porphyry	FT	Zircon	29.9	2.4
334	Lincoln Gulch stock	K-Ar	Biotite	34.8	1.1
186	Lincoln Porphyry	K-Ar	Biotite	29.8	2
202	Lincoln Porphyry	K-Ar	Biotite	30.8	2
183	Lincoln Porphyry	FT	Apatite	34.9	7.1
132	Lincoln Porphyry	FT	Apatite	36.7	3.9
203	Lincoln Porphyry	FT	Zircon	38.2	3.5
300	Lincoln Porphyry	FT	Zircon	38.7	4
207	Lincoln Porphyry	FT	Zircon	39.5	4
170	Lincoln Porphyry	FT	Zircon	39.9	3.6
140	Lincoln Porphyry	FT	Zircon	40.1	3.9
171	Lincoln Porphyry	FT	Apatite	40.7	7.5
120	Lincoln Porphyry	K-Ar	Biotite	41	2.1
133	Lincoln Porphyry	FT	Zircon	41.5	3.7
213	Lincoln Porphyry	FT	Apatite	42	7.6
184	Lincoln Porphyry	FT	Zircon	42.1	4.3
301	Lincoln Porphyry	FT	Apatite	42.1	6.8
214	Lincoln Porphyry	FT	Zircon	43.3	4.2
172	Lincoln Porphyry	FT	Sphene	43.7	6.6
241	Lincoln Porphyry	FT	Apatite	48.3	17
141	Lincoln Porphyry	FT	Apatite	48.6	6.6
215	Lincoln Porphyry	FT	Sphene	49.3	8
185	Lincoln Porphyry	K-Ar	Biotite	51.3	5
204	Lincoln Porphyry	FT	Apatite	56.4	11.1
216	Lincoln Porphyry	K-Ar	Biotite	65.6	
246	Lincoln Porphyry	K-Ar	Biotite	66.3	1.9
206	Lincoln Porphyry	Rb-Sr	Whole rock	67	
242	Lincoln Porphyry	FT	Zircon	73.6	8.2
217	Lincoln Porphyry	Pb-alpha	Zircon	530	60
323	Little Annie quartz-muscovite porphyry	K-Ar	Muscovite	74	2.2
305	Maroon Formation	FT	Zircon	648	186
187	Metalamprophyre	K-Ar	Biotite	1,328	66
354	Migmatite	FT	Apatite	27.9	3.9
117	Migmatite	FT	Apatite	65.9	23
145	Migmatite	K-Ar	Biotite	1,209	60
106	Migmatite	Pb-alpha	Zircon	1,280	14
146	Migmatite	K-Ar	Muscovite	1,298	65
147	Migmatite	Pb-alpha	Zircon	1,365	15
107	Migmatite	K-Ar	Biotite	1,368	68
73	Minturn Formation	FT	Apatite	32.9	4.5
64	Minturn Formation	FT	Apatite	38.9	15
66	Minturn Formation	FT	Apatite	213	32
35	Minturn Formation	FT	Zircon	231	31
65	Minturn Formation	FT	Zircon	542	95
75	Minturn Formation	FT	Zircon	550	71
74	Minturn Formation	FT	Zircon	562	84
67	Minturn Formation	FT	Zircon	994	150
179	Missouri Creek granodiorite	K-Ar	Biotite	70.8	3
176	Missouri Creek stock	K-Ar	Biotite	71.8	

Appendix C. Geochronologic data listed by unit name—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
338	Monitor rock plug	FT	Apatite	19.9	4.4
356	Mount Bellview quartz monzonite	K-Ar	Biotite(?)	24.2	1.4
261	Mount Sopris stock	FT	Zircon	34.2	3.7
262	Mount Sopris stock	K-Ar	Biotite	34.2	0.8
148	Mylonite	K-Ar	Whole rock	332	16
52	Pando Porphyry	FT	Apatite	28.7	22
62	Pando Porphyry	FT	Zircon	40.4	4.6
93	Pando Porphyry	FT	Apatite	41.1	32
45	Pando Porphyry	FT	Zircon	42.9	4.8
47	Pando Porphyry	FT	Zircon	44.5	5.2
39	Pando Porphyry	FT	Zircon	45.2	5.1
53	Pando Porphyry	FT	Zircon	45.9	4.3
54	Pando Porphyry	FT	Zircon	45.9	5.8
90	Pando Porphyry	FT	Zircon	46.6	5.8
38	Pando Porphyry	FT	Zircon	48	5.6
55	Pando Porphyry	FT	Zircon	48.2	7
109	Pando Porphyry	FT	Apatite	48.6	26.3
48	Pando Porphyry	FT	Zircon	49.7	5.6
83	Pando Porphyry	FT	Zircon	52.5	5
91	Pando Porphyry	FT	Zircon	53	7.9
110	Pando Porphyry	FT	Zircon	53.2	6.2
51	Pando Porphyry	FT	Zircon	53.4	6
36	Pando Porphyry	FT	Zircon	54.9	6.2
82	Pando Porphyry	FT	Zircon	55.2	6.6
253	Pando Porphyry	FT	Zircon	55.5	5.6
46	Pando Porphyry	FT	Zircon	56.4	8.4
37	Pando Porphyry	FT	Zircon	58.1	6.8
100	Pando Porphyry	FT	Zircon	58.9	7
94	Pando Porphyry	FT	Zircon	60.1	7.8
250	Pando Porphyry	FT	Zircon	60.6	6.8
256	Pando Porphyry	FT	Zircon	61.1	6.3
291	Pando Porphyry	K-Ar	Sericite	61.5	
40	Pando Porphyry	FT	Apatite	63	40
218	Pando Porphyry	FT	Zircon	67.7	7.7
92	Pando Porphyry	FT	Apatite	69	34
254	Pando Porphyry	K-Ar	Biotite	71.8	
219	Pando Porphyry	FT	Apatite	72.7	23.9
292	Pando Porphyry	Rb-Sr	Whole rock	100	11
173	Paragneiss	K-Ar	Biotite	92.3	5
188	Paragneiss	Pb-alpha	Zircon	1,170	13
258	Paragneiss	K-Ar	Biotite	1,240	62
134	Paragneiss	K-Ar	Biotite	1,264	63
189	Paragneiss	K-Ar	Biotite	1,358	68
174	Paragneiss	Pb-alpha	Zircon	1,405	16
135	Paragneiss	Pb-alpha	Zircon	1,495	16
180	Pegmatite	K-Ar	Muscovite	1,343	67
175	Pegmatite	K-Ar	Muscovite	1,368	68
352	Pine Creek stock	K-Ar	Biotite	35.7	1.2
353	Pine Creek stock	K-Ar	Biotite	36.8	1.4
156	Quail Porphyry	FT	Zircon	40.4	4.5
152	Quail Porphyry	FT	Apatite	41.6	10.4
153	Quail Porphyry	FT	Zircon	44.4	5.3
154	Quail Porphyry	FT	Apatite	45.3	8.3
157	Quail Porphyry	FT	Apatite	46.1	8.2
155	Quail Porphyry	FT	Zircon	51	5.1
119	Quartz latite dike	K-Ar	Biotite	62.2	1.7
136	Quartz latite dike	K-Ar	Sericite	63	1.5
303	Quartz latite dike	K-Ar	Biotite	63.9	2.3
329	Quartz latite dike	K-Ar	Biotite	65.4	2.4
314	Quartz latite dike	K-Ar	Biotite	399	15
122	Quartz latite porphyry	FT	Zircon	38.3	4.4
313	Quartz monzonite	FT	Apatite	28.7	5.3
320	Quartz monzonite	FT	Apatite	31.9	15
287	Quartz monzonite	FT	Apatite	51.1	5.5
311	Quartz monzonite	FT	Apatite	69.8	34
321	Quartz monzonite	FT	Zircon	451	74
312	Quartz monzonite	FT	Zircon	586	111
245	Quartz monzonite stock	K-Ar	Biotite	71.4	2.4
315	Quartz porphyry	FT	Apatite	22.3	9.2
316	Quartz porphyry	FT	Zircon	50	7.2
1	Rhyolite ash fall	FT	Zircon	12.8	2.3
351	Rhyolite porphyry	K-Ar	Biotite	61.4	2.2
347	Rhyolite porphyry	K-Ar	Whole rock	65.3	2.4
279	Rhyolite porphyry (Eureka pipe)	K-Ar	Sanidine	38.5	0.6
263	Sacramento Porphyry	FT	Zircon	43.9	4.3
232	Sacramento Porphyry	FT	Apatite	45.2	19

Appendix C. Geochronologic data listed by unit name—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
233	Sacramento Porphyry	FT	Zircon	53.6	6
355	Sawmill Stock, Grizzly Peak cauldron	K-Ar	Biotite	32.9	1.1
118	Silver Plume Granite	K-Ar	Biotite	1,150	30
309	Snowmass Creek sill	K-Ar	Biotite	32	1.1
330	Snowmass pluton	K-Ar	Biotite	35	1.4
222	St. Kevin Granite	K-Ar	Biotite	1,209	60
268	St. Kevin Granite	K-Ar	Biotite	1,210	61
274	St. Kevin Granite	K-Ar	Biotite	1,239	62
275	St. Kevin Granite	Rb-Sr	Biotite	1,250	63
223	St. Kevin Granite	Rb-Sr	Biotite	1,260	63
224	St. Kevin Granite	Rb-Sr	Muscovite	1,290	65
247	St. Kevin Granite	K-Ar	Biotite	1,309	65
276	St. Kevin Granite	Rb-Sr	K feldspar	1,310	13
225	St. Kevin Granite	K-Ar	Muscovite	1,358	68
248	St. Kevin Granite	Pb-alpha	Zircon	1,362	15
259	St. Kevin Granite	U-Th-Pb	Zircon	1,411	40
266	St. Kevin Granite	U-Th-Pb	Zircon	1,411	40
273	St. Kevin Granite	U-Th-Pb	Zircon	1,411	40
226	St. Kevin Granite	Rb-Sr	K feldspar	1,430	13
227	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
235	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
249	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
269	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
270	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
277	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
278	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
267	St. Kevin Granite	Pb-alpha	Zircon	1,505	17
34	Swan Mtn. quartz monzonite sill	Rb-Sr	Whole rock	44	
33	Swan Mtn. quartz monzonite sill	K-Ar	Biotite	44.1	1.6
229	Syenodiorite	FT	Apatite	44.2	13
230	Syenodiorite	FT	Zircon	48.4	4.9
231	Syenodiorite	FT	Sphene	64.7	18
257	Timberline Lake latite breccia	K-Ar	Sericite	35.9	1.2
349	Treasure Mountain granite	K-Ar	Biotite	12.8	0.6
162	Treasure Vault stock	FT	Apatite	52	15.7
161	Treasure Vault stock	K-Ar	Biotite	64	2.3
163	Treasure Vault stock	FT	Zircon	69.4	7.2
255	Treasurevault stock	K-Ar	Biotite(?)	1,430	45
114	Tucker Mountain quartz monzonite	FT	Apatite	36.7	3.8
116	Tucker Mountain quartz monzonite	FT	Zircon	41.8	3
121	Tucker Mountain quartz monzonite	K-Ar	Biotite	43.9	2
124	Tucker Mountain rhyolite porphyry	K-Ar	Sanidine(?)	36.1	1.4
123	Tucker Mountain rhyolite porphyry	FT	Zircon	39.5	4.5
260	Turquoise Lake porphyry	K-Ar	Sericite	35.6	1.4
339	Twin Lakes stock	FT	Apatite	20	2.9
345	Twin Lakes stock	FT	Apatite	29.9	4.2
340	Twin Lakes stock	FT	Sphene	39.2	4.2
343	Twin Lakes stock	K-Ar	Biotite	42.7	1.2
341	Twin Lakes stock	FT	Zircon	44.1	5
344	Twin Lakes stock	Rb-Sr	Biotite	49.7	4.5
342	Twin Lakes stock	Rb-Sr	Biotite	56	10
358	Twin Lakes stock	$^{40}Ar/^{39}Ar$	Hornblende	63.8	1.4
346	Twin Lakes stock aplite	FT	Apatite	16	2.4
103	Unnamed diorite	FT	Apatite	46.7	19
104	Unnamed diorite	FT	Zircon	758	11
137	West Cross Creek diorite	FT	Apatite	51.1	11
138	West Cross Creek stock	FT	Zircon	59.3	6.2
139	West Cross Creek stock	K-Ar	Biotite	61.8	1.4
208	West Tennessee Creek stock	FT	Apatite	46.4	9.8
209	West Tennessee Creek stock	K-Ar	Biotite	66.4	2.2
357	Whiterock pluton	K-Ar	Biotite	34.8	1

Appendix D. Geochronologic data listed by geochronologic method

[Method: C-14, carbon-14; FT, fission track; K-Ar, potassium-argon; Nd-Sm, neodymium-samarium; Pb-alpha, lead-alpha; Rb-Sr, rubidium-strontium; U-Th-Pb, uranium-thorium-lead]

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
358	Twin Lakes stock	$^{40}Ar/^{39}Ar$	Hornblende	63.8	1.4
32	Basalt–Dotsero	C-14	Wood	4,150 yr	300 yr
346	Twin Lakes stock aplite	FT	Apatite	16	2.4
338	Monitor rock plug	FT	Apatite	19.9	4.4
339	Twin Lakes stock	FT	Apatite	20	2.9
315	Quartz porphyry	FT	Apatite	22.3	9.2
282	Johnson Gulch Porphyry	FT	Apatite	24.6	12
78	Cross Creek Granite	FT	Apatite	25.5	5.7
354	Migmatite	FT	Apatite	27.9	3.9
52	Pando Porphyry	FT	Apatite	28.7	22
313	Quartz monzonite	FT	Apatite	28.7	5.3
60	Cross Creek Granite	FT	Apatite	29.2	18
76	Cross Creek Granite	FT	Apatite	29.7	4.9
345	Twin Lakes stock	FT	Apatite	29.9	4.2
320	Quartz monzonite	FT	Apatite	31.9	15
63	Cross Creek Granite	FT	Apatite	32.3	4.9
73	Minturn Formation	FT	Apatite	32.9	4.5
56	Hydrothermal apatite	FT	Apatite	34.5	4.4
183	Lincoln Porphyry	FT	Apatite	34.9	7.1
49	Cross Creek Granite	FT	Apatite	35.5	15
114	Tucker Mountain quartz monzonite	FT	Apatite	36.7	3.8
132	Lincoln Porphyry	FT	Apatite	36.7	3.9
57	Cross Creek Granite	FT	Apatite	38.2	10
64	Minturn Formation	FT	Apatite	38.9	15
80	Cross Creek Granite	FT	Apatite	39.6	11
88	Cross Creek Granite	FT	Apatite	39.8	18
71	Cross Creek Granite	FT	Apatite	40.1	24
171	Lincoln Porphyry	FT	Apatite	40.7	7.5
93	Pando Porphyry	FT	Apatite	41.1	32
95	Cross Creek Granite	FT	Apatite	41.5	11
152	Quail Porphyry	FT	Apatite	41.6	10.4
164	Elk Mountain Porphyry	FT	Apatite	41.9	9.5
213	Lincoln Porphyry	FT	Apatite	42	7.6
301	Lincoln Porphyry	FT	Apatite	42.1	6.8
77	Fulford stock	FT	Apatite	43.1	10
289	Johnson Gulch Porphyry	FT	Apatite	43.1	7.6
79	Cross Creek Granite	FT	Apatite	43.5	14
98	Cross Creek Granite	FT	Apatite	44.2	10
229	Syenodiorite	FT	Apatite	44.2	13
232	Sacramento Porphyry	FT	Apatite	45.2	19
154	Quail Porphyry	FT	Apatite	45.3	8.3
157	Quail Porphyry	FT	Apatite	46.1	8.2
208	West Tennessee Creek stock	FT	Apatite	46.4	9.8
103	Unnamed diorite	FT	Apatite	46.7	19
68	Cross Creek Granite	FT	Apatite	48.3	11
241	Lincoln Porphyry	FT	Apatite	48.3	17
109	Pando Porphyry	FT	Apatite	48.6	26.3
141	Lincoln Porphyry	FT	Apatite	48.6	6.6
101	Cross Creek Granite	FT	Apatite	50.8	24
137	West Cross Creek diorite	FT	Apatite	51.1	11
287	Quartz monzonite	FT	Apatite	51.1	5.5
159	Elk Mountain Porphyry	FT	Apatite	51.5	12.3
162	Treasure Vault stock	FT	Apatite	52	15.7
304	Granodiorite	FT	Apatite	52.8	12
182	Eagle River Porphyry	FT	Apatite	54.5	17
111	Cross Creek Granite	FT	Apatite	55.9	20
204	Lincoln Porphyry	FT	Apatite	56.4	11.1
85	Cross Creek Granite	FT	Apatite	58	21
40	Pando Porphyry	FT	Apatite	63	40
117	Migmatite	FT	Apatite	65.9	23
92	Pando Porphyry	FT	Apatite	69	34
311	Quartz monzonite	FT	Apatite	69.8	34
219	Pando Porphyry	FT	Apatite	72.7	23.9
66	Minturn Formation	FT	Apatite	213	32
340	Twin Lakes stock	FT	Sphene	39.2	4.2
172	Lincoln Porphyry	FT	Sphene	43.7	6.6
215	Lincoln Porphyry	FT	Sphene	49.3	8
231	Syenodiorite	FT	Sphene	64.7	18
113	East Lake Creek stock	FT	Sphene	65.3	5.5
1	Rhyolite ash fall	FT	Zircon	12.8	2.3
200	Climax–Seriate granite stock	FT	Zircon	18.2	0.9
192	Climax–"Central Mass"	FT	Zircon	23.3	1.1
199	Climax–Seriate granite stock	FT	Zircon	24.4	4.9

Appendix D. Geochronologic data listed by geochronologic method—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
195	Climax–late rhyolite porphyry	FT	Zircon	25.5	1.2
193	Climax–biotite rhyolite porphyry	FT	Zircon	26.1	1.2
236	Buckskin biotite granodiorite dike	FT	Zircon	27.6	3
285	Johnson Gulch Porphyry	FT	Zircon	28.8	4.2
22	Latite porphyry	FT	Zircon	29.9	2.4
23	Green Mountain trachyte dike	FT	Zircon	29.9	2.4
210	Grizzly Peak Tuff (outflow)	FT	Zircon	30.1	3
211	Grizzly Peak Tuff (outflow)	FT	Zircon	30.2	0.9
293	Johnson Gulch Porphyry	FT	Zircon	30.3	5
286	Johnson Gulch Porphyry	FT	Zircon	31.6	5.2
361	Badger Creek Tuff	FT	Zircon	31.6	3.1
294	Johnson Gulch Porphyry	FT	Zircon	32	5
295	Johnson Gulch Porphyry	FT	Zircon	32	5.4
362	Badger Creek Tuff	FT	Zircon	33	4
198	Climax–Rhyolite porphyry	FT	Zircon	33.2	2.1
296	Johnson Gulch Porphyry	FT	Zircon	33.8	6.4
283	Johnson Gulch Porphyry	FT	Zircon	34	3.9
297	Johnson Gulch Porphyry	FT	Zircon	34	5.4
360	Buffalo Peaks Andesite	FT	Zircon	34	3.5
261	Mount Sopris stock	FT	Zircon	34.2	3.7
220	Buckskin porphyritic rhyolite-A dike	FT	Zircon	34.9	4
149	Biotite rhyolite-B porphyry	FT	Zircon	35.5	3.2
284	Johnson Gulch Porphyry	FT	Zircon	35.5	4.5
359	Buffalo Peaks Andesite	FT	Zircon	37.1	3.4
158	Elk Mountain Porphyry	FT	Zircon	37.6	3.7
298	Johnson Gulch Porphyry	FT	Zircon	37.7	5.6
203	Lincoln Porphyry	FT	Zircon	38.2	3.5
122	Quartz latite porphyry	FT	Zircon	38.3	4.4
299	Johnson Gulch Porphyry	FT	Zircon	38.3	6
300	Lincoln Porphyry	FT	Zircon	38.7	4
123	Tucker Mountain rhyolite porphyry	FT	Zircon	39.5	4.5
207	Lincoln Porphyry	FT	Zircon	39.5	4
170	Lincoln Porphyry	FT	Zircon	39.9	3.6
140	Lincoln Porphyry	FT	Zircon	40.1	3.9
62	Pando Porphyry	FT	Zircon	40.4	4.6
156	Quail Porphyry	FT	Zircon	40.4	4.5
133	Lincoln Porphyry	FT	Zircon	41.5	3.7
116	Tucker Mountain quartz monzonite	FT	Zircon	41.8	3
184	Lincoln Porphyry	FT	Zircon	42.1	4.3
45	Pando Porphyry	FT	Zircon	42.9	4.8
290	Johnson Gulch Porphyry	FT	Zircon	43.1	4.3
214	Lincoln Porphyry	FT	Zircon	43.3	4.2
263	Sacramento Porphyry	FT	Zircon	43.9	4.3
341	Twin Lakes stock	FT	Zircon	44.1	5
153	Quail Porphyry	FT	Zircon	44.4	5.3
47	Pando Porphyry	FT	Zircon	44.5	5.2
39	Pando Porphyry	FT	Zircon	45.2	5.1
53	Pando Porphyry	FT	Zircon	45.9	4.3
54	Pando Porphyry	FT	Zircon	45.9	5.8
90	Pando Porphyry	FT	Zircon	46.6	5.8
272	Evans Gulch Porphyry	FT	Zircon	47	3.9
38	Pando Porphyry	FT	Zircon	48	5.6
55	Pando Porphyry	FT	Zircon	48.2	7
230	Syenodiorite	FT	Zircon	48.4	4.9
332	Aplite porphyry	FT	Zircon	48.7	5
48	Pando Porphyry	FT	Zircon	49.7	5.6
316	Quartz porphyry	FT	Zircon	50	7.2
165	Elk Mountain Porphyry	FT	Zircon	50.9	5.2
155	Quail Porphyry	FT	Zircon	51	5.1
306	Aplite porphyry	FT	Zircon	52.1	5
307	Aplite porphyry	FT	Zircon	52.1	4.4
83	Pando Porphyry	FT	Zircon	52.5	5
181	Eagle River Porphyry	FT	Zircon	52.9	6
91	Pando Porphyry	FT	Zircon	53	7.9
310	Aplite porphyry	FT	Zircon	53.1	4.9
110	Pando Porphyry	FT	Zircon	53.2	6.2
51	Pando Porphyry	FT	Zircon	53.4	6
318	Hornblende quartz diorite	FT	Zircon	53.4	5
233	Sacramento Porphyry	FT	Zircon	53.6	6
36	Pando Porphyry	FT	Zircon	54.9	6.2
82	Pando Porphyry	FT	Zircon	55.2	6.6
253	Pando Porphyry	FT	Zircon	55.5	5.6
46	Pando Porphyry	FT	Zircon	56.4	8.4
37	Pando Porphyry	FT	Zircon	58.1	6.8
308	Aplite porphyry	FT	Zircon	58.6	6.1
100	Pando Porphyry	FT	Zircon	58.9	7

Appendix D. Geochronologic data listed by geochronologic method—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
138	West Cross Creek stock	FT	Zircon	59.3	6.2
112	East Lake Creek stock	FT	Zircon	59.7	7.5
94	Pando Porphyry	FT	Zircon	60.1	7.8
250	Pando Porphyry	FT	Zircon	60.6	6.8
256	Pando Porphyry	FT	Zircon	61.1	6.3
87	Fulford stock	FT	Zircon	65.3	6
218	Pando Porphyry	FT	Zircon	67.7	7.7
163	Treasure Vault stock	FT	Zircon	69.4	7.2
242	Lincoln Porphyry	FT	Zircon	73.6	8.2
35	Minturn Formation	FT	Zircon	231	31
321	Quartz monzonite	FT	Zircon	451	74
58	Cross Creek Granite	FT	Zircon	486	64
81	Cross Creek Granite	FT	Zircon	500	96
65	Minturn Formation	FT	Zircon	542	95
75	Minturn Formation	FT	Zircon	550	71
74	Minturn Formation	FT	Zircon	562	84
312	Quartz monzonite	FT	Zircon	586	111
305	Maroon Formation	FT	Zircon	648	186
61	Cross Creek Granite	FT	Zircon	671	170
104	Unnamed diorite	FT	Zircon	758	11
69	Cross Creek Granite	FT	Zircon	766	180
96	Cross Creek Granite	FT	Zircon	771	170
302	Gothic Formation	FT	Zircon	852	288
99	Cross Creek Granite	FT	Zircon	877	200
89	Cross Creek Granite	FT	Zircon	904	250
67	Minturn Formation	FT	Zircon	994	150
50	Cross Creek Granite	FT	Zircon	Proterozoic	
72	Cross Creek Granite	FT	Zircon	Proterozoic	
86	Cross Creek Granite	FT	Zircon	Proterozoic	
102	Cross Creek Granite	FT	Zircon	Proterozoic	
237	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg. 3)	26.7	4
239	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg. 4)	43.9	5.6
238	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg. 7)	35.4	3.3
349	Treasure Mountain granite	K-Ar	Biotite	12.8	0.6
190	Chalk Mountain Rhyolite	K-Ar	Biotite	27.7	1.9
186	Lincoln Porphyry	K-Ar	Biotite	29.8	2
202	Lincoln Porphyry	K-Ar	Biotite	30.8	2
309	Snowmass Creek sill	K-Ar	Biotite	32	1.1
355	Sawmill Stock, Grizzly Peak cauldron	K-Ar	Biotite	32.9	1.1
348	Grizzly Peak Tuff	K-Ar	Biotite	33.3	1
335	Grizzly Peak Tuff	K-Ar	Biotite	33.4	1
262	Mount Sopris stock	K-Ar	Biotite	34.2	0.8
334	Lincoln Gulch stock	K-Ar	Biotite	34.8	1.1
357	Whiterock pluton	K-Ar	Biotite	34.8	1
330	Snowmass pluton	K-Ar	Biotite	35	1.4
352	Pine Creek stock	K-Ar	Biotite	35.7	1.2
129	Humbug stock	K-Ar	Biotite	35.8	2
128	Humbug stock	K-Ar	Biotite	35.9	1.4
212	Grizzly Peak Tuff (outflow)	K-Ar	Biotite	36.3	0.9
353	Pine Creek stock	K-Ar	Biotite	36.8	1.4
115	Elk Mountain Porphyry	K-Ar	Biotite	37.6	1.6
120	Lincoln Porphyry	K-Ar	Biotite	41	2.1
126	Humbug stock	K-Ar	Biotite	41.5	1
221	Granodiorite stock	K-Ar	Biotite	42.1	1.2
264	Johnson Gulch Porphyry	K-Ar	Biotite	42.1	
125	Humbug stock	K-Ar	Biotite	42.4	1
343	Twin Lakes stock	K-Ar	Biotite	42.7	1.2
151	Biotite rhyolite-B porphyry	K-Ar	Biotite	43.5	3
121	Tucker Mountain quartz monzonite	K-Ar	Biotite	43.9	2
33	Swan Mtn. quartz monzonite sill	K-Ar	Biotite	44.1	1.6
319	Halfmoon Creek stock	K-Ar	Biotite	44.3	1.6
127	Humbug stock	K-Ar	Biotite	44.7	2.1
130	Humbug stock	K-Ar	Biotite	48	2.2
185	Lincoln Porphyry	K-Ar	Biotite	51.3	5
317	Halfmoon Creek stock	K-Ar	Biotite	54.4	2
240	Biotite granodiorite stock	K-Ar	Biotite	55.9	2.5
351	Rhyolite porphyry	K-Ar	Biotite	61.4	2.2
139	West Cross Creek stock	K-Ar	Biotite	61.8	1.4
84	Fulford stock	K-Ar	Biotite	62.2	1.5
119	Quartz latite dike	K-Ar	Biotite	62.2	1.7
234	Buckskin Gulch granodiorite	K-Ar	Biotite	62.4	1.9
303	Quartz latite dike	K-Ar	Biotite	63.9	2.3
161	Treasure Vault stock	K-Ar	Biotite	64	2.3
177	Granodiorite	K-Ar	Biotite	64.6	3
329	Quartz latite dike	K-Ar	Biotite	65.4	2.4
178	Granodiorite	K-Ar	Biotite	65.6	3

Appendix D. Geochronologic data listed by geochronologic method—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
216	Lincoln Porphyry	K-Ar	Biotite	65.6	
246	Lincoln Porphyry	K-Ar	Biotite	66.3	1.9
209	West Tennessee Creek stock	K-Ar	Biotite	66.4	2.2
228	Buckskin Gulch leucogranite	K-Ar	Biotite	66.7	1.6
333	Aplite porphyry	K-Ar	Biotite	68.7	2.3
243	Buckskin Gulch dacite	K-Ar	Biotite	69.9	1.7
179	Missouri Creek granodiorite	K-Ar	Biotite	70.8	3
244	Buckskin Gulch melagranodiorite	K-Ar	Biotite	71.2	1.7
245	Quartz monzonite stock	K-Ar	Biotite	71.4	2.4
176	Missouri Creek stock	K-Ar	Biotite	71.8	
254	Pando Porphyry	K-Ar	Biotite	71.8	
196	Climax–Precambrian granite	K-Ar	Biotite	74.9	2.3
173	Paragneiss	K-Ar	Biotite	92.3	5
197	Climax–Precambrian granite	K-Ar	Biotite	96.4	2.9
314	Quartz latite dike	K-Ar	Biotite	399	15
169	Gneiss	K-Ar	Biotite	483	24
118	Silver Plume Granite	K-Ar	Biotite	1,150	30
143	Granite of Holy Cross City	K-Ar	Biotite	1,184	59
145	Migmatite	K-Ar	Biotite	1,209	60
222	St. Kevin Granite	K-Ar	Biotite	1,209	60
268	St. Kevin Granite	K-Ar	Biotite	1,210	61
274	St. Kevin Granite	K-Ar	Biotite	1,239	62
258	Paragneiss	K-Ar	Biotite	1,240	62
166	Hornblendite	K-Ar	Biotite	1,249	62
134	Paragneiss	K-Ar	Biotite	1,264	63
247	St. Kevin Granite	K-Ar	Biotite	1,309	65
44	Cross Creek Granite	K-Ar	Biotite	1,343	67
189	Paragneiss	K-Ar	Biotite	1,358	68
107	Migmatite	K-Ar	Biotite	1,368	68
42	Cross Creek Granite	K-Ar	Biotite	1,442	72
356	Mount Bellview quartz monzonite	K-Ar	Biotite(?)	24.2	1.4
255	Treasurevault stock	K-Ar	Biotite(?)	1,430	45
337	Grizzly Peak Tuff	K-Ar	Hornblende	33.8	1.1
167	Hornblendite	K-Ar	Hornblende	2,018	10
205	Climax porphyritic granite	K-Ar	Muscovite	30.3	1
323	Little Annie quartz-muscovite porphyry	K-Ar	Muscovite	74	2.2
146	Migmatite	K-Ar	Muscovite	1,298	65
180	Pegmatite	K-Ar	Muscovite	1,343	67
225	St. Kevin Granite	K-Ar	Muscovite	1,358	68
175	Pegmatite	K-Ar	Muscovite	1,368	68
279	Rhyolite porphyry (Eureka pipe)	K-Ar	Sanidine	38.5	0.6
150	Biotite rhyolite-B porphyry	K-Ar	Sanidine	40.2	2
124	Tucker Mountain rhyolite porphyry	K-Ar	Sanidine(?)	36.1	1.4
194	Climax–late barren stage sericite	K-Ar	Sericite	25.3	0.3
201	Climax–upper ore body sericite	K-Ar	Sericite	30.6	0.4
260	Turquoise Lake porphyry	K-Ar	Sericite	35.6	1.4
257	Timberline Lake latite breccia	K-Ar	Sericite	35.9	1.2
288	Johnson Gulch Porphyry	K-Ar	Sericite	39.6	1.7
291	Pando Porphyry	K-Ar	Sericite	61.5	
136	Quartz latite dike	K-Ar	Sericite	63	1.5
5	Basalt, nepheline-normative	K-Ar	Whole rock	0.66	0.2
251	Basalt, nepheline-normative	K-Ar	Whole rock	1.28	0.2
252	Basalt, nepheline-normative	K-Ar	Whole rock	2.03	0.3
160	Basalt	K-Ar	Whole rock	8.07	0.4
142	Basalt	K-Ar	Whole rock	8.91	0.4
131	Basalt	K-Ar	Whole rock	9.01	0.4
20	Basaltic andesite	K-Ar	Whole rock	9.9	0.5
350	Grand Mesa basalt	K-Ar	Whole rock	10	0.5
59	Basalt	K-Ar	Whole rock	10.4	0.5
3	Basaltic andesite	K-Ar	Whole rock	10.6	0.5
70	Basalt	K-Ar	Whole rock	11.4	1
21	Basaltic andesite	K-Ar	Whole rock	13.5	0.5
6	Basaltic andesite	K-Ar	Whole rock	13.8	0.5
8	Basalt	K-Ar	Whole rock	18	
24	Basalt	K-Ar	Whole rock	19	0.8
9	Basalt	K-Ar	Whole rock	20.4	
25	Basalt	K-Ar	Whole rock	20.4	0.8
26	Basalt	K-Ar	Whole rock	20.6	0.8
10	Basalt	K-Ar	Whole rock	21.1	
27	Basalt	K-Ar	Whole rock	21.2	0.8
28	Basalt	K-Ar	Whole rock	21.2	1
11	Basalt	K-Ar	Whole rock	21.6	
29	Basalt	K-Ar	Whole rock	22	1
12	Basalt	K-Ar	Whole rock	22.5	
13	Basalt	K-Ar	Whole rock	22.6	
7	Basalt	K-Ar	Whole rock	22.7	1

Appendix D. Geochronologic data listed by geochronologic method—Continued

Map No.	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
30	Basalt	K-Ar	Whole rock	22.8	1
14	Basalt	K-Ar	Whole rock	22.9	
2	Basalt	K-Ar	Whole rock	23.6	1
15	Basalt	K-Ar	Whole rock	23.6	
16	Basalt	K-Ar	Whole rock	23.6	
4	Basalt	K-Ar	Whole rock	23.8	1
17	Basalt	K-Ar	Whole rock	24.6	
18	Basalt	K-Ar	Whole rock	24.9	
19	Basalt	K-Ar	Whole rock	25.7	
347	Rhyolite porphyry	K-Ar	Whole rock	65.3	2.4
148	Mylonite	K-Ar	Whole rock	332	16
187	Metalamprophyre	K-Ar	Biotite	1,328	66
31	Felsic gneiss/amphibolite	Nd-Sm	Whole rock	1,800	90
265	Johnson Gulch Porphyry	Pb-alpha	Zircon	120	20
271	Johnson Gulch Porphyry	Pb-alpha	Zircon	130	20
217	Lincoln Porphyry	Pb-alpha	Zircon	530	60
43	Cross Creek Granite	Pb-alpha	Zircon	1,065	20
188	Paragneiss	Pb-alpha	Zircon	1,170	13
106	Migmatite	Pb-alpha	Zircon	1,280	14
41	Cross Creek Granite	Pb-alpha	Zircon	1,300	16
248	St. Kevin Granite	Pb-alpha	Zircon	1,362	15
147	Migmatite	Pb-alpha	Zircon	1,365	15
174	Paragneiss	Pb-alpha	Zircon	1,405	16
135	Paragneiss	Pb-alpha	Zircon	1,495	16
267	St. Kevin Granite	Pb-alpha	Zircon	1,505	17
144	Granite of Holy Cross City	Pb-alpha	Zircon	1,630	18
344	Twin Lakes stock	Rb-Sr	Biotite	49.7	4.5
342	Twin Lakes stock	Rb-Sr	Biotite	56	10
275	St. Kevin Granite	Rb-Sr	Biotite	1,250	63
223	St. Kevin Granite	Rb-Sr	Biotite	1,260	63
276	St. Kevin Granite	Rb-Sr	K feldspar	1,310	13
226	St. Kevin Granite	Rb-Sr	K feldspar	1,430	13
224	St. Kevin Granite	Rb-Sr	Muscovite	1,290	65
191	Climax sericite	Rb-Sr	Sericite	73	8
168	Climax mine	Rb-Sr	Sericite	74.8	8
34	Swan Mtn. quartz monzonite sill	Rb-Sr	Whole rock	44	
280	Evans Gulch Porphyry	Rb-Sr	Whole rock	64	
206	Lincoln Porphyry	Rb-Sr	Whole rock	67	
281	Johnson Gulch Porphyry	Rb-Sr	Whole rock	67	
292	Pando Porphyry	Rb-Sr	Whole rock	100	11
324	Feldspathic gneiss	Rb-Sr	Whole rock	1,395	35
227	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
235	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
249	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
269	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
270	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
277	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
278	St. Kevin Granite	Rb-Sr	Whole rock	1,436	72
322	Feldspathic gneiss	Rb-Sr	Whole rock	1,520	
105	Granite gneiss	Rb-Sr	Whole rock	1,650	35
108	Cross Creek Granite dike	Rb-Sr	Whole rock	1,650	9
331	Granite (Denny Creek?)	Rb-Sr	Whole rock	1,650	35
336	Granite (Denny Creek?)	Rb-Sr	Whole rock	1,650	35
328	Feldspathic gneiss	Rb-Sr	Whole rock	1,670	
325	Feldspathic gneiss	Rb-Sr	Whole rock	1,700	
97	Cross Creek Granite	Rb-Sr	Whole rock	1,710	
326	Feldspathic gneiss	Rb-Sr	Whole rock	1,750	
327	Feldspathic gneiss	Rb-Sr	Whole rock	1,970	
259	St. Kevin Granite	U-Th-Pb	Zircon	1,411	40
266	St. Kevin Granite	U-Th-Pb	Zircon	1,411	40
273	St. Kevin Granite	U-Th-Pb	Zircon	1,411	40

Appendix E. Geochronologic data listed by mining district

[Method: C-14, carbon-14; FT, fission track; K-Ar, potassium-argon; Nd-Sm, neodymium-samarium; Pb-alpha, lead-alpha; Rb-Sr, rubidium-strontium; U-Th-Pb, uranium-thorium-lead]

Map No.	Mining district	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
237	Alma	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg.3)	26.7	4
236	Alma	Buckskin biotite granodiorite dike	FT	Zircon	27.6	3
220	Alma	Buckskin porphyritic rhyolite-A dike	FT	Zircon	34.9	4
238	Alma	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg.7)	35.4	3.3
221	Alma	Granodiorite stock	K-Ar	Biotite	42.1	1.2
239	Alma	Buckskin porphyritic rhyolite-B dike	FT	Zircon (avg.4)	43.9	5.6
240	Alma	Biotite granodiorite stock	K-Ar	Biotite	55.9	2.5
234	Alma	Buckskin Gulch granodiorite	K-Ar	Biotite	62.4	1.9
228	Alma	Buckskin Gulch leucogranite	K-Ar	Biotite	66.7	1.6
206	Alma	Lincoln Porphyry	Rb-Sr	Whole rock	67	
243	Alma	Buckskin Gulch dacite	K-Ar	Biotite	69.9	1.7
244	Alma	Buckskin Gulch melagranodiorite	K-Ar	Biotite	71.2	1.7
245	Alma	Quartz monzonite stock	K-Ar	Biotite	71.4	2.4
315	Aspen	Quartz porphyry	FT	Apatite	22.3	9.2
354	Aspen	Migmatite	FT	Apatite	27.9	3.9
313	Aspen	Quartz monzonite	FT	Apatite	28.7	5.3
320	Aspen	Quartz monzonite	FT	Apatite	31.9	15
332	Aspen	Aplite porphyry	FT	Zircon	48.7	5
316	Aspen	Quartz porphyry	FT	Zircon	50	7.2
287	Aspen	Quartz monzonite	FT	Apatite	51.1	5.5
306	Aspen	Aplite porphyry	FT	Zircon	52.1	5
307	Aspen	Aplite porphyry	FT	Zircon	52.1	4.4
304	Aspen	Granodiorite	FT	Apatite	52.8	12
310	Aspen	Aplite porphyry	FT	Zircon	53.1	4.9
318	Aspen	Hornblende quartz diorite	FT	Zircon	53.4	5
308	Aspen	Aplite porphyry	FT	Zircon	58.6	6.1
311	Aspen	Quartz monzonite	FT	Apatite	69.8	34
323	Aspen	Little Annie quartz-muscovite porphyry	K-Ar	Muscovite	74	2.2
321	Aspen	Quartz monzonite	FT	Zircon	451	74
312	Aspen	Quartz monzonite	FT	Zircon	586	111
305	Aspen	Maroon Formation	FT	Zircon	648	186
302	Aspen	Gothic Formation	FT	Zircon	852	288
34	Breckenridge	Swan Mtn. quartz monzonite sill	Rb-Sr	Whole rock	44	
33	Breckenridge	Swan Mtn. quartz monzonite sill	K-Ar	Biotite	44.1	1.6
200	Climax	Climax–Seriate granite stock	FT	Zircon	18.2	0.9
192	Climax	Climax–"Central Mass"	FT	Zircon	23.3	1.1
199	Climax	Climax–Seriate granite stock	FT	Zircon	24.4	4.9
194	Climax	Climax–late barren stage sericite	K-Ar	Sericite	25.3	0.3
195	Climax	Climax–late rhyolite porphyry	FT	Zircon	25.5	1.2
193	Climax	Climax–biotite rhyolite porphyry	FT	Zircon	26.1	1.2
190	Climax	Chalk Mountain Rhyolite	K-Ar	Biotite	27.7	1.9
186	Climax	Lincoln Porphyry	K-Ar	Biotite	29.8	2
205	Climax	Climax porphyritic granite	K-Ar	Muscovite	30.3	1
201	Climax	Climax–upper ore body sericite	K-Ar	Sericite	30.6	0.4
202	Climax	Lincoln Porphyry	K-Ar	Biotite	30.8	2
198	Climax	Climax–Rhyolite porphyry	FT	Zircon	33.2	2.1
185	Climax	Lincoln Porphyry	K-Ar	Biotite	51.3	5
168	Climax	Climax mine	Rb-Sr	Sericite	74.8	8
196	Climax	Climax–Precambrian granite	K-Ar	Biotite	74.9	2.3
197	Climax	Climax–Precambrian granite	K-Ar	Biotite	96.4	2.9
78	Gilman	Cross Creek Granite	FT	Apatite	25.5	5.7
52	Gilman	Pando Porphyry	FT	Apatite	28.7	22
60	Gilman	Cross Creek Granite	FT	Apatite	29.2	18
76	Gilman	Cross Creek Granite	FT	Apatite	29.7	4.9
63	Gilman	Cross Creek Granite	FT	Apatite	32.3	4.9
73	Gilman	Minturn Formation	FT	Apatite	32.9	4.5
56	Gilman	Hydrothermal apatite	FT	Apatite	34.5	4.4
49	Gilman	Cross Creek Granite	FT	Apatite	35.5	15
57	Gilman	Cross Creek Granite	FT	Apatite	38.2	10
64	Gilman	Minturn Formation	FT	Apatite	38.9	15
80	Gilman	Cross Creek Granite	FT	Apatite	39.6	11
88	Gilman	Cross Creek Granite	FT	Apatite	39.8	18
71	Gilman	Cross Creek Granite	FT	Apatite	40.1	24
62	Gilman	Pando Porphyry	FT	Zircon	40.4	4.6
93	Gilman	Pando Porphyry	FT	Apatite	41.1	32
95	Gilman	Cross Creek Granite	FT	Apatite	41.5	11
45	Gilman	Pando Porphyry	FT	Zircon	42.9	4.8
79	Gilman	Cross Creek Granite	FT	Apatite	43.5	14
98	Gilman	Cross Creek Granite	FT	Apatite	44.2	10
47	Gilman	Pando Porphyry	FT	Zircon	44.5	5.2
39	Gilman	Pando Porphyry	FT	Zircon	45.2	5.1
53	Gilman	Pando Porphyry	FT	Zircon	45.9	4.3
54	Gilman	Pando Porphyry	FT	Zircon	45.9	5.8

Appendix E. Geochronologic data listed by mining district—Continued

Map No.	Mining district	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
90	Gilman	Pando Porphyry	FT	Zircon	46.6	5.8
103	Gilman	Unnamed diorite	FT	Apatite	46.7	19
38	Gilman	Pando Porphyry	FT	Zircon	48	5.6
55	Gilman	Pando Porphyry	FT	Zircon	48.2	7
68	Gilman	Cross Creek Granite	FT	Apatite	48.3	11
48	Gilman	Pando Porphyry	FT	Zircon	49.7	5.6
101	Gilman	Cross Creek Granite	FT	Apatite	50.8	24
83	Gilman	Pando Porphyry	FT	Zircon	52.5	5
91	Gilman	Pando Porphyry	FT	Zircon	53	7.9
51	Gilman	Pando Porphyry	FT	Zircon	53.4	6
36	Gilman	Pando Porphyry	FT	Zircon	54.9	6.2
82	Gilman	Pando Porphyry	FT	Zircon	55.2	6.6
46	Gilman	Pando Porphyry	FT	Zircon	56.4	8.4
85	Gilman	Cross Creek Granite	FT	Apatite	58	21
37	Gilman	Pando Porphyry	FT	Zircon	58.1	6.8
100	Gilman	Pando Porphyry	FT	Zircon	58.9	7
94	Gilman	Pando Porphyry	FT	Zircon	60.1	7.8
40	Gilman	Pando Porphyry	FT	Apatite	63	40
92	Gilman	Pando Porphyry	FT	Apatite	69	34
66	Gilman	Minturn Formation	FT	Apatite	213	32
35	Gilman	Minturn Formation	FT	Zircon	231	31
58	Gilman	Cross Creek Granite	FT	Zircon	486	64
81	Gilman	Cross Creek Granite	FT	Zircon	500	96
65	Gilman	Minturn Formation	FT	Zircon	542	95
75	Gilman	Minturn Formation	FT	Zircon	550	71
74	Gilman	Minturn Formation	FT	Zircon	562	84
61	Gilman	Cross Creek Granite	FT	Zircon	671	170
104	Gilman	Unnamed diorite	FT	Zircon	758	11
69	Gilman	Cross Creek Granite	FT	Zircon	766	180
96	Gilman	Cross Creek Granite	FT	Zircon	771	170
99	Gilman	Cross Creek Granite	FT	Zircon	877	200
89	Gilman	Cross Creek Granite	FT	Zircon	904	250
67	Gilman	Minturn Formation	FT	Zircon	994	150
50	Gilman	Cross Creek Granite	FT	Zircon	Proterozoic	
72	Gilman	Cross Creek Granite	FT	Zircon	Proterozoic	
86	Gilman	Cross Creek Granite	FT	Zircon	Proterozoic	
102	Gilman	Cross Creek Granite	FT	Zircon	Proterozoic	
351	Granite	Rhyolite porphyry	K-Ar	Biotite	61.4	2.2
333	Hayden Peak	Aplite porphyry	K-Ar	Biotite	68.7	2.3
129	Kokomo	Humbug stock	K-Ar	Biotite	35.8	2
128	Kokomo	Humbug stock	K-Ar	Biotite	35.9	1.4
124	Kokomo	Tucker Mountain rhyolite porphyry	K-Ar	Sanidine(?)	36.1	1.4
114	Kokomo	Tucker Mountain quartz monzonite	FT	Apatite	36.7	3.8
132	Kokomo	Lincoln Porphyry	FT	Apatite	36.7	3.9
115	Kokomo	Elk Mountain Porphyry	K-Ar	Biotite	37.6	1.6
158	Kokomo	Elk Mountain Porphyry	FT	Zircon	37.6	3.7
122	Kokomo	Quartz latite porphyry	FT	Zircon	38.3	4.4
123	Kokomo	Tucker Mountain rhyolite porphyry	FT	Zircon	39.5	4.5
140	Kokomo	Lincoln Porphyry	FT	Zircon	40.1	3.9
156	Kokomo	Quail Porphyry	FT	Zircon	40.4	4.5
120	Kokomo	Lincoln Porphyry	K-Ar	Biotite	41	2.1
126	Kokomo	Humbug stock	K-Ar	Biotite	41.5	1
133	Kokomo	Lincoln Porphyry	FT	Zircon	41.5	3.7
152	Kokomo	Quail Porphyry	FT	Apatite	41.6	10.4
116	Kokomo	Tucker Mountain quartz monzonite	FT	Zircon	41.8	3
164	Kokomo	Elk Mountain Porphyry	FT	Apatite	41.9	9.5
125	Kokomo	Humbug stock	K-Ar	Biotite	42.4	1
121	Kokomo	Tucker Mountain quartz monzonite	K-Ar	Biotite	43.9	2
153	Kokomo	Quail Porphyry	FT	Zircon	44.4	5.3
127	Kokomo	Humbug stock	K-Ar	Biotite	44.7	2.1
154	Kokomo	Quail Porphyry	FT	Apatite	45.3	8.3
157	Kokomo	Quail Porphyry	FT	Apatite	46.1	8.2
130	Kokomo	Humbug stock	K-Ar	Biotite	48	2.2
141	Kokomo	Lincoln Porphyry	FT	Apatite	48.6	6.6
165	Kokomo	Elk Mountain Porphyry	FT	Zircon	50.9	5.2
155	Kokomo	Quail Porphyry	FT	Zircon	51	5.1
159	Kokomo	Elk Mountain Porphyry	FT	Apatite	51.5	12.3
282	Leadville	Johnson Gulch Porphyry	FT	Apatite	24.6	12
285	Leadville	Johnson Gulch Porphyry	FT	Zircon	28.8	4.2
293	Leadville	Johnson Gulch Porphyry	FT	Zircon	30.3	5
286	Leadville	Johnson Gulch Porphyry	FT	Zircon	31.6	5.2
294	Leadville	Johnson Gulch Porphyry	FT	Zircon	32	5
295	Leadville	Johnson Gulch Porphyry	FT	Zircon	32	5.4
296	Leadville	Johnson Gulch Porphyry	FT	Zircon	33.8	6.4
283	Leadville	Johnson Gulch Porphyry	FT	Zircon	34	3.9
297	Leadville	Johnson Gulch Porphyry	FT	Zircon	34	5.4

Appendix E. Geochronologic data listed by mining district—Continued

Map No.	Mining district	Unit name	Method	Mineral	Age (Ma)	Analytical uncertainty
284	Leadville	Johnson Gulch Porphyry	FT	Zircon	35.5	4.5
298	Leadville	Johnson Gulch Porphyry	FT	Zircon	37.7	5.6
299	Leadville	Johnson Gulch Porphyry	FT	Zircon	38.3	6
279	Leadville	Rhyolite porphyry (Eureka pipe)	K-Ar	Sanidine	38.5	0.6
288	Leadville	Johnson Gulch Porphyry	K-Ar	Sericite	39.6	1.7
289	Leadville	Johnson Gulch Porphyry	FT	Apatite	43.1	7.6
290	Leadville	Johnson Gulch Porphyry	FT	Zircon	43.1	4.3
263	Leadville	Sacramento Porphyry	FT	Zircon	43.9	4.3
272	Leadville	Evans Gulch Porphyry	FT	Zircon	47	3.9
280	Leadville	Evans Gulch Porphyry	Rb-Sr	Whole rock	64	
281	Leadville	Johnson Gulch Porphyry	Rb-Sr	Whole rock	67	
356	Mt. Bellview	Mount Bellview quartz monzonite	K-Ar	Biotite(?)	24.2	1.4
183	Tennessee Pass	Lincoln Porphyry	FT	Apatite	34.9	7.1
149	Tennessee Pass	Biotite rhyolite-B porphyry	FT	Zircon	35.5	3.2
203	Tennessee Pass	Lincoln Porphyry	FT	Zircon	38.2	3.5
300	Tennessee Pass	Lincoln Porphyry	FT	Zircon	38.7	4
207	Tennessee Pass	Lincoln Porphyry	FT	Zircon	39.5	4
170	Tennessee Pass	Lincoln Porphyry	FT	Zircon	39.9	3.6
150	Tennessee Pass	Biotite rhyolite-B porphyry	K-Ar	Sanidine	40.2	2
171	Tennessee Pass	Lincoln Porphyry	FT	Apatite	40.7	7.5
213	Tennessee Pass	Lincoln Porphyry	FT	Apatite	42	7.6
184	Tennessee Pass	Lincoln Porphyry	FT	Zircon	42.1	4.3
301	Tennessee Pass	Lincoln Porphyry	FT	Apatite	42.1	6.8
214	Tennessee Pass	Lincoln Porphyry	FT	Zircon	43.3	4.2
151	Tennessee Pass	Biotite rhyolite-B porphyry	K-Ar	Biotite	43.5	3
172	Tennessee Pass	Lincoln Porphyry	FT	Sphene	43.7	6.6
229	Tennessee Pass	Syenodiorite	FT	Apatite	44.2	13
232	Tennessee Pass	Sacramento Porphyry	FT	Apatite	45.2	19
241	Tennessee Pass	Lincoln Porphyry	FT	Apatite	48.3	17
230	Tennessee Pass	Syenodiorite	FT	Zircon	48.4	4.9
109	Tennessee Pass	Pando Porphyry	FT	Apatite	48.6	26.3
215	Tennessee Pass	Lincoln Porphyry	FT	Sphene	49.3	8
181	Tennessee Pass	Eagle River Porphyry	FT	Zircon	52.9	6
110	Tennessee Pass	Pando Porphyry	FT	Zircon	53.2	6.2
233	Tennessee Pass	Sacramento Porphyry	FT	Zircon	53.6	6
182	Tennessee Pass	Eagle River Porphyry	FT	Apatite	54.5	17
253	Tennessee Pass	Pando Porphyry	FT	Zircon	55.5	5.6
204	Tennessee Pass	Lincoln Porphyry	FT	Apatite	56.4	11.1
250	Tennessee Pass	Pando Porphyry	FT	Zircon	60.6	6.8
256	Tennessee Pass	Pando Porphyry	FT	Zircon	61.1	6.3
231	Tennessee Pass	Syenodiorite	FT	Sphene	64.7	18
218	Tennessee Pass	Pando Porphyry	FT	Zircon	67.7	7.7
219	Tennessee Pass	Pando Porphyry	FT	Apatite	72.7	23.9
242	Tennessee Pass	Lincoln Porphyry	FT	Zircon	73.6	8.2

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