Preliminary Geologic Map of the North Half of the Union Pass 7.5′ Quadrangle, Mohave County, Arizona

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The lower volcanics of Union Pass including basaltic andesite lavas (Tbal) and tuffaceous rocks (Tts).

CONTRIBUTED MAP CM-13-A

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APPENDIX A – DETAILED ROCK DESCRIPTIONS

QUATERNARY

Qmd – Mine dump (late Holocene) Mine tailings and constructions obscuring surface geology in the vicinity of the Frisco and Tyro mines.

Qay – Younger alluvial deposits (late Holocene) Unconsolidated gravels including locally derived pebble to boulder size clasts composed of Proterozoic megacrystic granite and orthogneiss and the volcanics of Union Pass in a coarse-grained, subangular sand matrix; inset into Qao and Qai.

Qai – Intermediate alluvial deposits (late Holocene) Unconsolidated gravels including locally derived pebble to boulder size clasts composed of Proterozoic megacrystic granite and orthogneiss and the volcanics of Union Pass in a coarse-grained, subangular sand matrix; inset into Qao.

Qc – Colluvium (late Holocene) Unconsolidated, locally derived slope wash.

Qls – Landslide deposits (late Holocene) Very poorly sorted, matrix supported slump deposits dominated by cobble to large boulder size clasts of Miocene andesite and rhyolite in a coarse pebble and sand matrix (e.g., NE ¼ of section 4, T21N, R20W).

Qrf – Rockfall deposits (late Holocene) Angular cobble to boulder size blocks of Miocene rhyolite shed from rhyolite domes along the range crest of the southern Black Mountains (e.g., section 10, T21N, R20W).

Qao – Older alluvial deposits (Pleistocene) Unconsolidated gravels including locally derived pebble to boulder size clasts composed of Proterozoic megacrystic granite and orthogneiss and the volcanics of Union Pass in a coarse-grained, subangular sand matrix.

MIOCENE

Ta – Alluvium (late Miocene) As exposed in the SW part of the map area, this unit is a tan, moderately to poorly sorted, weakly indurated, non-calcareous, matrix supported fanglomerate with angular to subangular pebble- to cobble- and boulder- (to ~1.5 m) size clasts in a subangular coarse sand matrix; clast lithologies include rhyolite, dacite, andesite, basaltic andesite, and megacrystic granite (Ygu); rhyolite is the dominant clast lithology, though clasts of Proterozoic granite are abundant; where present, pebble imbrication indicates deposition by approximately west-flowing streams; as exposed along the northern margin of the map area (e.g., sections 31 and 32, T21N, R20W), this conglomerate consists of poorly sorted, matrix supported gravels with subangular to angular pebble to cobble size clasts in a subangular coarse sand matrix; major clast lithologies include rhyolite, dacite, andesite, and basalt; the gravel surface is dominated by angular vesicular basalt boulders as large as 1 m; weathered exposures prevent observation of degree and type of induration, though some clasts are entirely coated in pedogenic carbonate; this unit represents a middle- to late-Miocene alluvial fan sequence derived from basement rocks and Miocene volcanics exposed in the Union Pass area.

Tf_2 – Fanglomerate (middle to late Miocene) Tan, poorly sorted, moderately indurated, matrix supported conglomerate with angular to subrounded pebble-, cobble-, and boulder- (to 2 m) size clasts in an angular coarse sand matrix with calcareous cement; rhyolite is the dominant clast lithology (generally 80-100%), though clasts of dacite, andesite, basaltic andesite, megacrystic granite (Ygu), and pegmatite are observed in many exposures; boulders are rare and consist exclusively of rhyolite; this unit is only exposed in the SW part of the map area and represents a middle- to late-Miocene alluvial fan sequence derived from basement rocks and Miocene volcanics exposed in the Union Pass area.

Tc, $Tbay_2$

Tc – Conglomerate (middle Miocene) Generally <10 m thick; tan to reddish-purple, very poorly sorted,

well indurated, matrix supported conglomerate; clasts are angular Proterozoic basement (Ygu), large basement-derived K-feldspar crystals, subangular Miocene rhyolite clasts, and rare andesite and basalt clasts in a medium- to coarse-grained subangular sand matrix; clast size ranges from pebbles to boulders with rare rhyolite boulders as large as 1 m and boulders of megacrystic granite as large as ~2.5 m; though both clasts and matrix appear locally derived, provenance varies as some exposures are dominated by Proterozoic basement clasts (75-80%) and others by Miocene rhyolite clasts (to ~80%); thin basaltic andesite and andesite lavas ($Tbay_2$) are intercalated with this conglomerate in some parts of the graben; this conglomerate is locally well-exposed, but commonly weathers to rounded low-relief hills with a surficial lag of Proterozoic and Miocene clasts; though generally poorly exposed, the basal contact with rhyolite lavas (Trl), granitic megabreccia (Tbg), and rhyolite breccia (Tbr) is sharp and erosional; this unit is best exposed in the northern part of the graben between the Union Pass and Frisco Mine faults in the north-central part of the map area (e.g., sections 4, 5, 8, and 9, T21N, R20W).

$Tbay_2$ – Youngest basaltic andesite and andesite lavas (middle Miocene) Generally less than 10 m thick; basaltic andesite and andesite lavas associated with the upper volcanics of Union Pass are locally intercalated with middle Miocene conglomerate (Tc) in the northern part of the graben between the Union Pass and Frisco Mine faults (e.g., section 5, T21N, R20W); dark-gray, locally vesicular basaltic andesite lavas contain sparse fine-grained iddingsitized olivine in an aphyric groundmass; gray andesite flows contain partially resorbed subhedral plagioclase (An_{61}) (.25-3 mm) (3-20%) and acicular and subhedral oxyhornblende (to 1 mm) (2-7%) phenocrysts in a plagioclase microlite groundmass; sparse fine-grained pyroxene phenocrysts are observed in some andesites; some flows in this unit contain partially resorbed feldspar xenocrysts and small xenoliths apparently derived from the surrounding Proterozoic and Miocene sections; lavas are locally silicified and weather gray to reddish-brown in outcrop.

Tbr – Rhyolite breccia (middle Miocene) White, moderately indurated, poorly sorted, clast supported monolithologic breccia composed of angular Miocene rhyolite (Trl, Tri) pebble to boulder (to 60 cm) size clasts in an angular coarse-grained rhyolite sand matrix; this unit is restricted to one isolated exposure in the northern part of the graben between the Union Pass and Frisco Mine faults in the north-central part of the map area (e.g., SE ¼ of section 5, T21N, R20W); directly overlies granitic megabreccia (Tbg).

Tbg – Granitic megabreccia (middle Miocene) Brown, poorly indurated, very poorly sorted, clast supported, monolithologic megabreccia composed of angular weathered Proterozoic basement (Ygu) blocks; includes both jigsaw and crackle breccia facies (c.f., Yarnold and Lombard, 1989); clasts are generally cobble to boulder size in a coarse arkosic pebble and sand matrix; individual blocks may be several meters to tens of meters in length; this unit is generally poorly exposed in the northern part of the graben between the Union Pass and Frisco Mine faults in the north-central part of the map area (e.g., sections 5, 8, and 9, T21N, R20W).

Tf – Fanglomerate (middle to late Miocene) Greater than 200 m thick where exposed in the NE corner of the map area; tan to brown, poorly sorted, moderately indurated, matrix or clast supported conglomerate with angular to subangular pebble-, cobble-, and boulder- (to 2 m) size clasts in a subangular, medium- to coarse-grained volcaniclastic sand matrix with calcareous cement; clast lithologies include rhyolite, andesite, basaltic andesite, and basalt; in some intervals clasts are composed entirely of basaltic andesite (~90%) and basalt (~10%); boulders are more common in this area relative to fanglomerates exposed to the SW (Tf_2); the boulder-size fraction is dominated by basalt and basaltic andesite lithologies; sedimentary structures include crude bedding and coarsen-up sequences associated with transitions from matrix to clast supported conglomerate; nearly flat-lying layers at the top of this sequence are poorly sorted, moderately well indurated pebble conglomerates with subangular to subrounded rhyolite pebbles (~95%) and lesser andesite and basalt pebbles in a medium to coarse sand matrix with calcareous cement; this unit represents a middle- to late-Miocene alluvial fan sequence derived primarily from nearby volcanic rocks.

Upper volcanics of Union Pass (middle Miocene) 350 to 550 m thick sequence of basalt, basaltic andesite, and andesite lavas and breccias; age range is 16.2 to ~13.7 Ma (Fig. 10 and Appendix B); best exposed in sections 34 and 35 (T22N, R20W) and in sections 2 and 3 (T21N, R20W).

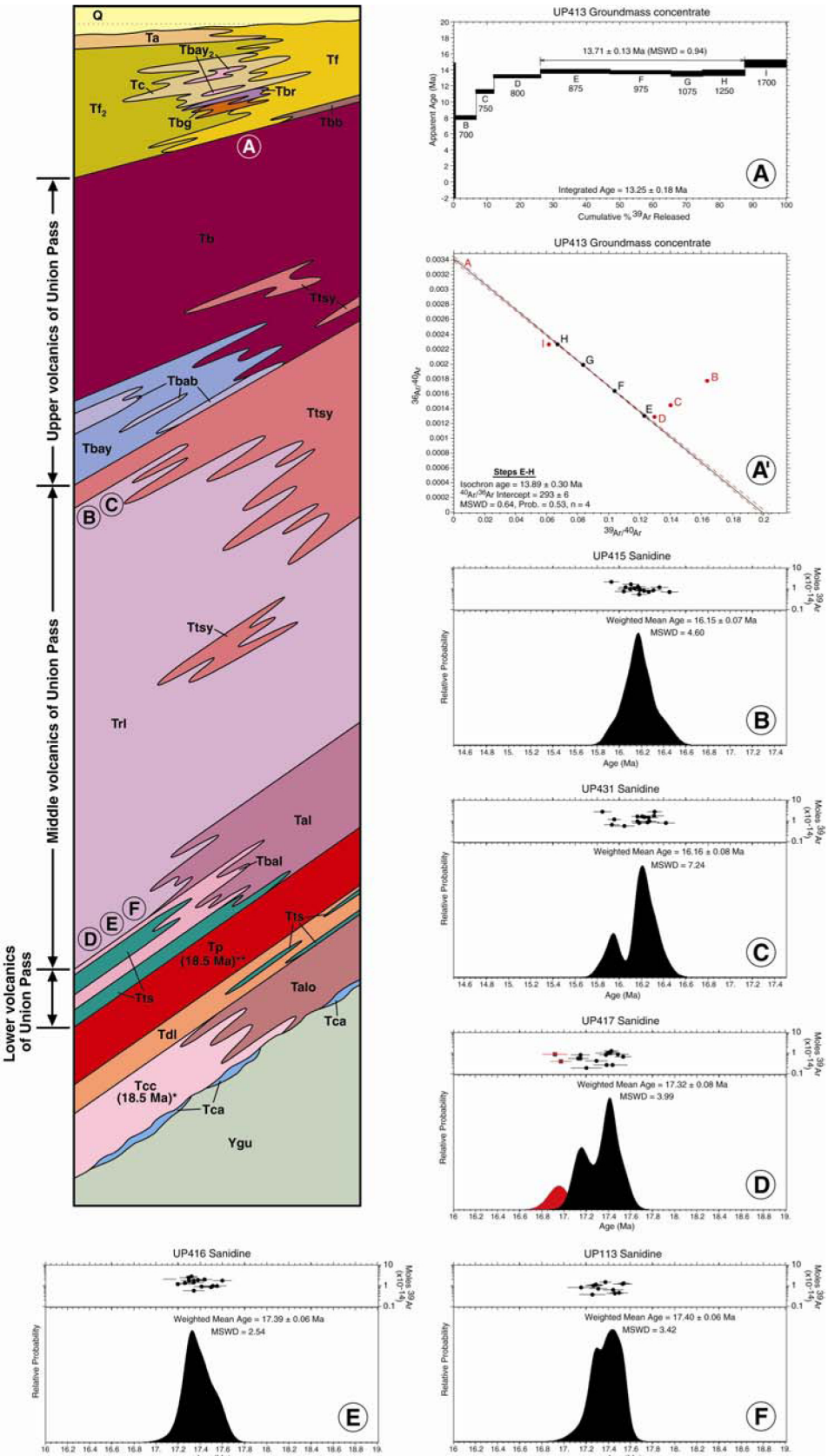
Q
Ta
Tbay2
Tf
Tc
Tbr
Tf2
Tbg
Tbb
A
Tb
Ttsy
Tbab
Ttsy
Tbay
B
C
Ttsy
Trl
Tal
Tbal
D
E
F
Tts
Tp
(18.5 Ma)**
Tts
Talo
Tca
Tdl
Tcc
(18.5 Ma)*
Tca
Ygu
Upper volcanics of Union Pass
Middle volcanics of Union Pass
Lower volcanics of Union Pass
UP413 Groundmass concentrate
13.71 ± 0.13 Ma (MSWD = 0.94)
Apparent Age (Ma)
B 700
C 750
D 800
E 875
F 975
G 1075
H 1250
I 1700
Integrated Age = 13.25 ± 0.18 Ma
Cumulative % 39Ar Released
A
UP413 Groundmass concentrate
36Ar/40Ar
39Ar/40Ar
Steps E-H
Isochron age = 13.89 ± 0.30 Ma
40Ar/36Ar Intercept = 293 ± 6
MSWD = 0.64, Prob. = 0.53, n = 4
A'
UP415 Sanidine
Weighted Mean Age = 16.15 ± 0.07 Ma
MSWD = 4.60
Moles 39Ar (x10-14)
Relative Probability
Age (Ma)
B
UP431 Sanidine
Weighted Mean Age = 16.16 ± 0.08 Ma
MSWD = 7.24
C
UP417 Sanidine
Weighted Mean Age = 17.32 ± 0.08 Ma
MSWD = 3.99
D
UP416 Sanidine
Weighted Mean Age = 17.39 ± 0.06 Ma
MSWD = 2.54
E
UP113 Sanidine
Weighted Mean Age = 17.40 ± 0.06 Ma
MSWD = 3.42
F

Figure 10 (previous page). Generalized stratigraphic column from the Union Pass area showing relative unit thicknesses, approximate tilt magnitudes, and $^{40}Ar/^{39}Ar$ ideograms, age spectra, and isochrons for dated samples. Bold letters in stratigraphic column correspond to approximate stratigraphic positions of dated samples. All errors on assigned ages are 2σ. The data in red on isochron A' and ideogram D are not included in age calculations. *Age for Tcc from Faulds (unpublished). **Age for Tp from Nielson et al. (1990). Lithologic units: Ygu, undifferentiated Proterozoic crystalline rocks; Tca, arkosic conglomerate; Tcc, tuff of Cook Canyon; Talo, older andesite lavas; Tts, tuffaceous rocks; Tdl, dacite lavas; Tp, Peach Springs Tuff; Tts, tuffaceous rocks; Tbal, basaltic andesite lavas; Tal, andesite lavas; Trl, rhyolite lavas; Ttsy, younger tuffaceous rocks; Tbay, younger basaltic andesite lavas; Tbab, basaltic andesite breccia; Tb, basalt lavas; Tbb, basalt breccia; Tf, fanglomerates; Tf_2, younger fanglomerates; Tbg, granitic megabreccia; Tbr, rhyolite breccia; Tc, conglomerate; $Tbay_2$, youngest basaltic andesite lavas; Ta, alluvium; Q, undifferentiated Quaternary deposits.

Tbb – Basalt breccia Reddish-brown, moderately to well indurated, very poorly sorted, clast supported breccia with angular pebble to boulder (to ~1 m) size clasts of vesicular basalt in an angular coarse basalt sand matrix with silica cement; basalt clasts are weathered and vesicles are commonly filled with silica; this unit is only locally exposed in the SE ¼ of section 3 (T21N, R20W).

Tb, Tbay, Tbab

Tb – Basalt lavas Up to 400 m thick; black, locally vesicular, generally aphyric basalt lavas exposed in the NE corner of the map area; some flows contain sparse, fine-grained, iddingsitized olivine phenocrysts in an aphyric groundmass; other flows contain subhedral lathic plagioclase (.25-1.5 mm) (2-3%) and subhedral orthopyroxene (.25 mm) (trace) phenocrysts in a plagioclase microlite and glass groundmass; reaction rims are common in plagioclase phenocrysts; numerous individual lava flows overlie basaltic autobreccia and minor tuffaceous rocks (Ttsy) intercalated at the base of the sequence; several basalt dikes cut Ttsy at the top of the middle volcanics of Union Pass and probably represent primary feeders for the basalt lava sequence.

Tbay – Younger basaltic andesite lavas Up to 150 m thick; dark gray to black basaltic andesite lavas are generally aphyric to sparsely porphyritic with < 3% fine- to medium-grained iddingsitized olivine phenocrysts in an aphyric groundmass; some flows contain medium-grained plagioclase phenocrysts (up to 15-20%); basaltic andesite lavas locally contain breccia (Tbab) in meter-scale discontinuous lenses and persistent ledges up to tens of meters thick; minor dark gray andesite flows are also locally intercalated; andesite flows generally contain 1-3% fine- to medium-grained hornblende or biotite phenocrysts in an aphyric groundmass; this unit generally weathers light gray to brown in outcrop.

Tbab – Basaltic andesite breccia Dark gray to brown, very poorly sorted, well indurated, matrix or clast supported breccia with angular pebble to boulder (to ~1 m) size clasts of basaltic andesite in a subangular coarse sand matrix with siliceous cement; breccias are intercalated with basaltic andesite lavas (Tbay) and probably represent debris flows, flow breccias, and rock avalanche deposits.

Middle volcanics of Union Pass (early to middle Miocene) Up to 650 m thick sequence of rhyolite lavas (Trl) and domes (Trl+Tri) and associated tuffaceous rocks (Ttsy); age range is 17.4 to 16.2 Ma (Fig. 10 and Appendix B).

Ttsy – Younger tuffaceous rocks 50 to 300 m thick; white to tan, moderately to well indurated, rhyolitic tuffaceous sandstone and conglomerate; finer-grained intervals are moderately to well sorted and commonly thinly bedded (cm scale) with subangular rhyolite pebbles in a tuffaceous matrix; individual conglomerate intervals are generally much thicker (meters to a few tens of meters) than finer-grained layers; conglomerate intervals are poorly sorted and may be clast or matrix supported with angular to subangular pebble- to cobble- and rare boulder-size rhyolite clasts in a tuffaceous matrix; sparse rhyolite lava flow autobreccias (up to 15 m thick) are locally intercalated with volcaniclastic layers; much of this unit is pumice rich; these deposits likely represent reworked non-welded tuffs and rhyolite lavas close to the vent; lower portions of Ttsy are probably laterally equivalent to the youngest rhyolite lavas of the middle volcanics of Union Pass; upper portions of Ttsy are intercalated with basalt lavas at the base of the upper volcanics of Union Pass; this unit is only exposed in the NE part of the map area.

Trl, Trl+Tri

Trl – Rhyolite lavas Generally well exposed throughout the map area; these lavas may be up to 650 m thick; major components of individual rhyolite flows include basal tuffaceous rocks and breccias, a lower devitrified zone, locally massive vitrophyres, an upper devitrified zone, and an upper breccia; the base of a distinct flow commonly includes tan to pink autobreccia or poorly to moderately welded explosion breccia with angular rhyolite clasts and pumice (up to 20 cm) in an ashy groundmass; locally, basal breccias overlie thin, meter-scale tuffaceous layers including volcaniclastic sandstones and reworked ash-fall tuffs; tuffaceous layers pinch out laterally over short distances and mark contacts between individual lava flows; white to pink to purple or tan to greenish-gray devitrified flow zones are ~15 to 45 m thick and contain subhedral sanidine (.25-2.5 mm) (3-7%), biotite (.25-1 mm) (to 1%),

plagioclase (An_{62}) (.25-1.25 mm) (trace), and anhedral quartz (.25-2 mm) (to 5%) phenocrysts in a flow-banded, aphanitic groundmass; some thin-sections contain subhedral clinopyroxene (.25-.5 mm) (to 1%) phenocrysts; euhedral sphene (.25-.75 mm) is a common accessory; total phenocryst content is generally low (less than 10%) but may be up to 20%; sanidine is rarely adularescent; groundmass in some thin-sections is microlitic sanidine ± quartz and/or brown or colorless glass; flow alignment is common in biotite grains; lithic rhyolite fragments and pumice (.5-4 mm) are generally rare; devitrified zones commonly exhibit axiolitic devitrification spherulites and rheomorphic flow; sparse vugs contain vapor phase quartz; dark brown to black glass vitrophyres (0-40m thick) are characterized by gradational devitrification into underlying and overlying devitrified zones; vitrophyres pinch out and swell laterally over tens to a few hundreds of meters and lenses commonly form resistant ledges; upper devitrified zones contain abundant lithophysae and vapor phase mineralization; a thin autobreccia carapace is present at the top of some flows.

Trl+Tri – Rhyolite lavas with lesser intrusive rhyolite Rhyolite lavas intruded by rhyolite dikes of similar composition; this unit is associated with thick rhyolite dome complexes along the range crest of the southern Black Mountains near Union Pass where thick lava flow aprons (Trl+Tri) radiate outward from central dome-throat intrusions (Tri); flow-banding in a lava apron commonly dips shallowly away from a central plug characterized by subvertical flow-banding; in the S part of the map area (e.g., section 11, T21N, R21W and sections 20 and 21, T21N, R20W), locally intense hydrothermal alteration accompanies this unit.

Lower volcanics of Union Pass (early Miocene) 50 to 450 m thick section of mafic to intermediate lavas and lesser tuffaceous rocks; age range is 18.5 to 17.4 Ma (Fig. 10 and Appendix B); in SW part of map area (e.g., section 14, T21N, R21W) this sequence is ~75 m thick and includes mafic and intermediate lavas (Tbal) and tuffaceous rocks (Tts); in NE part of map area (e.g., sections 32 and 33, T22N, R20W) the lower volcanics of Union Pass include thick (possibly >450 m) dominantly andesitic intermediate lavas (Tal).

Tbal, Tal

Tbal – Basaltic andesite and andesite lavas 10 to 25 m thick; lavas include dark gray, aphyric basaltic andesite and porphyritic andesite with subhedral lathic plagioclase (An_{55-63}) (.25-3 mm) (to 15%), and acicular and subhedral oxyhornblende (to 3 mm) (to 15%) or sparse fine-grained subhedral biotite (<2 mm) phenocrysts in a plagioclase microlite groundmass; pilotaxitic flow lineation texture observed in some thin-sections; these locally vesicular lavas commonly weather brown in outcrop and have cleavage subparallel to flow giving outcrops a platy appearance; marginal exposure and similar weathering characteristics preclude consistent distinction between these lavas and other basaltic andesite lavas slightly lower in the sequence of the lower volcanics of Union Pass.

Tal – Dominantly andesitic intermediate lavas may exceed 450 m thickness in some areas; flows are mostly porphyritic andesite with fine- to medium-grained plagioclase > hornblende >> biotite phenocrysts; some flows contain subhedral lathic plagioclase (.25-3 mm) (to 5%) and biotite (.25-1.5 mm) (1-3%) in a plagioclase microlite groundmass; andesite lavas are dominant but may include minor porphyritic dacite flows (Tal+Tdl), rhyolite flows (Tal+Trl), or both (Tal+Trl+Tdl); some andesite lavas are aphyric; where exposed in roadcuts along old Highway 68 near the summit of Union Pass, this unit contains a dark gray to brown basaltic andesite flow with subhedral plagioclase (An_{67}) (.25-2.5 mm) (20%) and clinopyroxene (.25-.5 mm) (to ~5%) phenocrysts in a plagioclase microlite groundmass with interstitial clinopyroxene; some flows have vesicular tops, weak flow banding, discontinuous autobreccia lenses and rare columnar jointing; this unit commonly weathers reddish- or purplish-brown in outcrop.

Tts – Older tuffaceous rocks ~30m thick; this unit includes intercalated, thinly bedded volcaniclastic sandstones and locally reworked non-welded tuffs, rare conglomerates, and minor ash-fall tuffs; white to greenish-tan to pink volcaniclastic sandstone is weakly to moderately indurated and moderately to well sorted with layers of subangular to angular, medium- to coarse-grained sand and subangular to subrounded pebbles (to 4cm) and rarely angular, cobble to boulder size (to 1m) rhyolite clasts; light brown conglomerates include subrounded pebble and cobble size rhyolite, dacite, and andesite clasts (to 30 cm) in a moderately indurated coarse sand matrix; white reworked tuffs and crystal-rich, pumiceous

ash-fall tuffs contain sanidine >> biotite > plagioclase > quartz phenocrysts and angular rhyolite lithic fragments in a non-welded groundmass; thickness of intercalated layers is generally ~10 cm; sedimentary structures commonly include fine laminations or centimeter scale fining-upwards or coarsening-upwards sequences; upper and lower contacts are generally planar and sharp.

Tbal – Basaltic andesite lavas 3 to ~20 m thick; dark gray, sparsely porphyritic basaltic andesite lavas with medium-grained iddingsitized olivine (?) phenocrysts in an aphyric groundmass; commonly weathers reddish-brown or light gray in rubbly outcrops; sharp planar contacts at base with Tts or Tp and at top with Tts; marginal exposure and similar weathering characteristics preclude consistent distinction between these lavas and other basaltic andesite and andesite lavas slightly higher in the sequence of the lower volcanics of Union Pass.

Tts – Older tuffaceous rocks ~15 m thick; see Tts description above.

Tp – Peach Springs Tuff (early Miocene) 60 to 100 m thick; orange, densely welded, phenocryst-rich (up to 35%) rhyolite ash-flow tuff with broken subhedral sanidine (.25-3 mm) (7-12%), biotite (.25-2 mm) (1%), plagioclase (.25-2 mm) (trace), anhedral quartz (.5-2 mm) (trace) and sparse subhedral sphene (.25-.5 mm) and zircon (.25 mm) and angular rhyolite lithic fragments (to 5 mm) in a devitrified groundmass; generally well developed compaction foliation; abundant devitrified fiamme with ~6:1 flattening ratio; devitrified groundmass commonly includes anhedral quartz aggregates; groundmass in some thin-sections is brown glass; based on stratigraphic position and phenocryst assemblage this tuff correlates with the 18.5 Ma (Nielson et al., 1990) Peach Springs Tuff (e.g., Young and Brennan, 1974; Glazner et al., 1986); sphene is sparse in this tuff in the Union Pass area but is relatively abundant (~1%) throughout most of its distribution; this tuff is distinguished from the tuff of Cook Canyon by abundant sanidine and relatively sparse biotite and lithic fragments; best exposed in the W ½ of section 14 (T21N, R21W).

Tdl, Tts

Tdl – Dacite lavas (early Miocene) 15 to ~50 m thick; gray dacite lavas with commonly altered, subhedral plagioclase (An_{44-58}) (.25-7 mm) (5-15%), clinopyroxene (.25-2 mm) (to 5%), and biotite (.25-1.5 mm) (to 1%) phenocrysts in a plagioclase microlite groundmass with pilotaxitic, weakly flow lineated texture; locally, thin tuffaceous layers are present at the base of, or intercalated with these lavas (e.g., NE corner of map area); best exposed in the W ½ of section 14 (T21N, R21W).

Tts – Tuffaceous rocks (early Miocene) <10 m thick; tuffaceous layers locally present at the base of, or intercalated with Tdl; see Tts description below.

Tcc, Talo

Tcc – Tuff of Cook Canyon (early Miocene) 50 to 100 m thick; gray, densely welded, phenocryst-rich rhyodacite ash-flow tuff with broken subhedral plagioclase (An_{45}) (.25-3 mm) (8%), biotite (.25-4 mm) (3-4%), sanidine (.25-1 mm) (trace), and anhedral quartz (.25-.1 mm) (trace) phenocrysts and abundant (~3-5%) angular lithic rhyolite and andesite fragments (to 3 mm) in an ashy groundmass; poorly to well developed compaction foliation; based on stratigraphic position and phenocryst assemblage this tuff correlates with the 18.5 Ma (Faulds, unpublished) tuff of Cook Canyon (e.g., Buesch and Valentine, 1986); this tuff is distinguished from the Peach Springs Tuff by abundant plagioclase and relatively abundant biotite and lithic fragments; best exposed in W ½ of section 14 (T21N, R21W); missing from the section in the NE corner of the map area.

Talo – Older mostly andesitic lavas (early Miocene) ~150 m thick; poorly exposed lavas at the base of the volcanic section in the NE corner of the map area where the tuff of Cook Canyon is missing; lavas include gray to brown, porphyritic andesite with lesser gray, porphyritic dacite and dark gray, aphyric basaltic andesite lavas.

Tca, Tcat

Tca – Arkosic conglomerate (early Miocene) Up to 70 m thick; Reddish- to purplish-brown, poorly sorted, matrix supported arkosic conglomerate with angular to subangular pebble to boulder size clasts of Proterozoic granite and orthogneiss and individual basement-derived K-feldspar grains in a poorly to

moderately indurated, medium- to coarse-grained, angular sand matrix; intercalated with coarser intervals are moderately indurated, moderately well sorted, and thinly bedded layers (1-5 cm) composed of angular fine- to coarse-grained sand and sparse subrounded pebble clasts with crude fining-upwards sequences and small-scale scour and fill structures; rests nonconformably on Proterozoic basement rocks; best exposed in SW ¼ of section 11 and NW ¼ of section 14 (T21N, R21W).

Tcat – Tuffaceous rocks (early Miocene) White to pink, thinly bedded tuffaceous layers (≤ 1 m thick) locally intercalated with Tca.

MIOCENE INTRUSIONS

Tbai, Tbi

Tbai – Basaltic andesite dikes (middle Miocene) Dark-gray to black, sparsely porphyritic basaltic andesite dikes with fine-grained plagioclase phenocrysts in an aphyric groundmass; exposed only in the NE corner of the map area (e.g., section 2, T21N, R20W); these dikes cut Ttsy at the top of the middle volcanics of Union Pass and probably served as primary feeders for mafic lavas in the upper volcanics of Union Pass.

Tbi – Basalt dikes (middle Miocene) Black, aphyric basalt dikes; exposed only in the NE corner of the map area (e.g., section 2, T21N, R20W); these dikes cut Ttsy at the top of the middle volcanics of Union Pass and probably served as primary feeders for mafic lavas in the upper volcanics of Union Pass.

Tri – Rhyolite dikes, domes, and plugs (early to middle Miocene) Commonly silicified, pink or gray, porphyritic rhyolite with altered subhedral sanidine (.25-3.5 mm) (3-5%), plagioclase (An_{56-64}) (.25-2 mm) (to 4%), biotite (.25-1 mm) (trace), and anhedral quartz (.25-.5 mm) (trace) phenocrysts in an aphanitic groundmass; subhedral cristobalite (.25-.5 mm) is an accessory in some thin-sections; sanidine is commonly partially resorbed; sparse secondary Fe-Mg minerals form microcrystalline aggregates; groundmass in some thin-sections consists of sanidine microlites and/or brown or colorless glass; flow banding is commonly pronounced and generally mimics dike orientation; dikes are generally tens of centimeters to a few meters in thick, but may be as thick as 1 km (e.g., Tyro dike, section 17, T21N, R20W); in the SW part of the map area (e.g., section 11, T21N, R21W) rhyolite plugs up to several hundred meters in diameter intrude Proterozoic basement rocks, earlier andesite plugs, and the base of the Miocene section as high as the Peach Springs Tuff (Tp); throughout the map area rhyolite intrusions consistently cut andesite and dacite intrusions; massive rhyolite intrusion with a minor component of rhyolite lavas (Tri+Trl) is associated with the roots of a dome complex exposed in the hanging wall of the Arabian Mine fault (e.g., sections 20 and 21, T21N, R20W); rare rhyolite breccia “pipes” and dikes are exposed in a few locations; breccias are generally intensely silicified and contain angular fragments of rhyolite in a matrix of aphanitic, subvertically flow-banded rhyolite; rhyolite intrusions in the Union Pass area are probably associated with the middle volcanics of Union Pass.

Tai – Andesite dikes and plugs (early Miocene) Dark gray, porphyritic andesite intrusions with altered subhedral plagioclase (.25-1 mm) (to 13%), hornblende (.25-1.5 mm) (to 7%), and biotite (.25-.5 mm) (trace) in a plagioclase microlite groundmass; individual dikes intruding Proterozoic basement rocks in the footwall of the Union Pass fault are generally tens of centimeters to a few meters thick; pervasively altered intrusive(?) andesite with fine-grained plagioclase > biotite in an aphanitic groundmass is intruded by massive rhyolite in the hanging wall of the Arabian Mine fault (e.g., SW ¼ of section 21, T21N, R20W); in the SW part of the map area (e.g., section 11, T21N, R21W) andesite plugs up to several hundred meters in diameter intrude Proterozoic basement rocks and the base of the Miocene section; andesite intrusions in the Union Pass area are probably associated with the lower volcanics of Union Pass.

Tdi – Dacite dikes and plugs (early Miocene) Pink to gray, augite-bearing, porphyritic dacite intrusions with subhedral plagioclase (.5-3 mm) (~2%) and clinopyroxene (.5-4 mm) (~2%) phenocrysts in a felty plagioclase and clinopyroxene microlite groundmass; subhedral cristobalite (.25-.5 mm) is an accessory in some thin-sections; argillic alteration of plagioclase is common; individual dikes intruding Proterozoic basement rocks in the footwall of the Union Pass fault are generally tens of centimeters to a few meters thick; in the SE part of the map area (e.g., sections 21 and 22, T21N, R20W) dacite plugs up to ~1 km in

diameter intrude Proterozoic basement rocks and the base of the Miocene section in the hanging wall of the Frisco Mine fault; dacite intrusions in the Union Pass area are probably associated with the lower volcanics of Union Pass.

Tqv – Quartz veins and pods (early Miocene) Colorless to white, massive and lesser crystalline quartz in centimeter to several meter thick veins cutting Proterozoic basement rocks (Ygu); these hydrothermal deposits generally correspond to diffuse zones of silicified basement rock and probably fill pre-Tertiary and Miocene fractures and faults; in some outcrops anastamosing quartz veinlets resemble silicified fault breccia; the largest quartz vein in the area (~1 km long) is gold-bearing and is exposed in the open stope of the defunct Tyro Mine (e.g., SE ¼ of section 6, T21N, R21W).

Tpg – Pegmatite dikes (early Miocene) White, coarse-grained pegmatite dikes generally <2 m thick intruding Proterozoic basement rocks (Ygu); composed of anhedral quartz (.25-4 mm) (86%), and subhedral muscovite (.25-1.5 mm) (10%), plagioclase (An_{61}) (.25-6 mm) (4%) and garnet (to .75 mm) (trace); texture is hypidiomorphic inequigranular; relative freshness and abundant muscovite distinguishes these Miocene pegmatite intrusions from Proterozoic pegmatites (Ypg).

PROTEROZOIC

Ydb – Diabase dikes and pods (Proterozoic) Dark-gray to greenish-brown intrusions cutting megacrystic granite and orthogneiss; texture is holocrystalline subophitic porphyry with subhedral lathic plagioclase (.25-3 mm) (79%) and interstitial subhedral clinopyroxene (to 1 mm).

Ypg – Pegmatite dikes (Proterozoic) Sparse, pink, coarse-grained felsic dikes intruding megacrystic granite and orthogneiss; mostly composed of coarse-grained (generally >1 cm) quartz ≈ K-feldspar > plagioclase phenocrysts with a granular texture.

Yap – Aplite dikes (Proterozoic) Sparse, pink, fine-grained felsic dikes intruding megacrystic granite and orthogneiss; dikes contain quartz > K-feldspar ± plagioclase.

Ygu – Undifferentiated megacrystic granite and orthogneiss (Proterozoic) Gray megacrystic granite, foliated granite, and orthogneiss; megacrystic granite contains subhedral, plagioclase-rimmed orthoclase and lesser microcline phenocrysts (.5 mm to 7 cm) (62-64%), anhedral quartz (.25-6 mm) (20-25%), and subhedral biotite (.25-2 mm) (2-12%); subhedral apatite (to .25 mm) is an accessory in some thin-sections; fibrous sericite is a common feldspar and biotite alteration product; thin-section texture is hypidiomorphic inequigranular; perthitic texture with albite exsolution lamellae is common in orthoclase; bending of some orthoclase grains is evident in lamellae; biotite grains are commonly bent; orthogneiss is locally strongly foliated with clearly defined mafic and felsic bands ~ 5-35 cm thick; both granite and gneiss locally contain partially resorbed subhedral garnet (.5-4 mm) (to 3%); megacrystic granite facies correlates with Davis Dam granite of Faulds and House (2000); this unit is locally dilated by Proterozoic diabase, pegmatite, and aplite dikes and early- to middle-Miocene basalt to rhyolite dikes and quartz and calcite veins; commonly weathers green or dark red and holds up resistant ridges in some areas but degrades to rubbly outcrops and rounded hills in low-lying areas.

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