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			riews and conclusions contained in this document are those of the authors uld not be interpreted as necessarily representing the official policies, either
consolidated, clast-supported	Glassy andesite porphyry intrusions and flows (late Eocene to Oligocene) –	_	expressed or implied, of the U.S. government. Hornblende-phyric intrusions (Eocene) – The unit includes prominent, vertical, east-
Mass-wasting processes are g depositional contacts where	Blue-gray to black, glassy, aphyric to sparsely porphyritic andesite lava flows and domes that are unconformable across and intrude older Eocene deposits, including the tuff of Steins Pillar	Tcih	west trending dikes and a small plug exposed near the intersection of McKay and Allen Creeks. The dike exposed through sec. 15, 16, and 17, T.13 S., R. 16. E. can be followed discontinuously
(Tjtw) and late Eocene Clarno in older deeply eroded surface es (Tcal; Tcdp), and 2) along long the inferred margin of the	(Tcts). The unit forms blocky to massive, platy to columnar-jointed outcrops that weather to platy and boulder armored surfaces. Vesicle-rich zones occur in places along the margins of flows and domes. Chemically, the unit ranges from andesite to low-silica dacite with 60.68 to 63.67 weight percent SiO_2 ; 15.78 to 17.08 weight percent Al_2O_3 ; and 1.13 to 2.37 weight percent K ₂ O		for ~2.5 km, is 4 to 6 m thick, and has well-developed horizontal columnar jointing. A small, 20 to 25 m wide, vertically jointed plug is exposed along McKay Creek in the NW ¼ of sec. 23, T. 13 S., R. 16 E. Bingert (1984) interpreted this outcrop as a possible feeder to an autobrecciated plagioclase-, hornblende-phyric dacite flows exposed directly above the plug.
deposits elevated above the	(Samples 1, 15 and 22; Table 1; Figure 1). The unit contains relatively low levels of barium (463 to 644 ppm Ba) and niobium (10.9 to 20.4 ppm Nb). Locally, a gravel composed of clasts of the tuff of Steins Pillar (Tcts) is exposed at the base of glassy andesite flows. Unit Tcag is inferred to	Tcdg	Dacite of Green Mountain (Eocene) – Blue to gray, variably altered, feldspar- and pyroxene-phyric dacite intrusion that is nonconformable into unit Tcal and unit Tcdp south of
eposits consist of gravel, brown ly 20 m. Equivalent in part to	be late Eocene to Oligocene in age on the basis of unconformable stratigraphic relations above the the rhyolite of Hash Rock (Tcrh) and upper andesite flows of unit Tcau.		Green Spring. The age relations between the unit Tcdg intrusion and the Rhyolite of Hash Rock (Tcrh) are unknown. Outcrops of the dacite are bulbous massive, to tabular- and columnar-
nd unit Qs of Swanson (1969). ary rocks	Rhyolite of Hash Rock (middle Eocene) – Light gray to purple gray, aphyric to sparsely sanidine-phyric, flow-banded, devitrified rhyolite flows that form a distinct plateau in the		jointed with a subvertical to vertical flow foliation. The south part of the intrusion, exposed at the head of Dry Creek (NE ¼, sec. 15, T. 13 S., R. 17 E.) is characterized by distinct columnar jointing. Columns are up to 1 m across, have an internal platy fabric, and sweep from subvertical
s, and vent rocks.	northeast corner of the map area. Includes ring-fracture rhyolite domes, flows, and shallow intrusions exposed near Strickland Butte and a rhyolite breccia, prominently exposed along the		at the base of the outcrop to vertical orientations near the top of the exposure. The unit weathers to a dark gray to orange and is covered by a grus-like soil mantle. In thin section, the unit is a
to medium-grained, closed- ply eroded Oligocene-Eocene	upper reach of Lemon Creek. Correlative, plateau-forming rhyolite flows, in the adjacent Steins Pillar 7.5' quadrangle rest conformably upon intracaldera fill (Tcts). The unit is exposed as a cliff- former in the northeast part of the map area and forms muted ridges near Strickland Butte.		medium-grained, seriate-textured, plagioclase-(? alkali-feldpsar), clinopyroxene-, biotite-phyric dacite. Phenocrysts are partially altered to sericite and are enclosed in a fine-grained, equigranular groundmass of feldspar and intergranular, opaque iron-oxide minerals. On the
nd is also exposed as intracan- nob-forming outcrops between	Outcrops typically have well-developed flow banding and folding, weather to a brown-red color, and form surfaces armored by platy, angular rock chips. Locally the bases of rhyolite flows are		basis of geochemical analysis the unit is a dacite, with 68.66 weight percent SiO ₂ ; 16.13 weight percent Al ₂ O ₃ ; 0.54 TiO ₂ ; and 2.12 weight percent K ₂ O (Sample 13; Table 1; Figure 1). The dacite
gray weathering, massive to marked by flattened, irregular ng. In thin section, euhedral to	marked by spherulite and lythophasae-rich zones and a fresh-appearing vitrophyre that weath- ers to subround boulders. At Strickland Butte, lythophasae developed in devitrified rhyolite are		is marked by relatively high levels of barium (715 ppm Ba) and low levels of niobium (11.3 ppm Nb). The intrusion is flanked by large landslide deposits, derived from the high-angle contact
o 2 mm across are enclosed in plagioclase and intergranular	cored by lenticular- and star-shaped fillings of banded brown and white agate, bubble agate, and oplaine quartz. Between Squirrel Ridge and Lemon Creek, coincident with the inferred Wildcat caldera margin (sec. 12, 13, 15 T. 13 S., R. 17 E.), the rhyolite is bleached white, silicified, and		between unit Tcal and Tcdg. Rhyolite of Mill Creek (Eocene) – Tan to orange, massive to columnar-jointed, cliff-
mpositions ranging from 49.11 D ₃ ; 1.10 to 1.80 weight percent	displays propylitic alteration (epidote and chlorite). In thin section, the rhyolite is fine-grained and sparsely phyric, with < 5 percent of sanidine and hornblende phenocrysts. Phenocrysts are	Tcrm	forming, flow-banded aphyric to plagioclase- and sanidine-phyric rhyolite that is unconformable across unit Tcal in the southeast corner of the map area. Includes distinct hoodoo-forming
4 and 38; Table 1; Figure 1). of Gradstein and others, 2004) ⁄la) of similar basalt exposed	enclosed in a fine-grained, hypohyalline matrix composed of devitrified glass and equigranular feldspar microlites. Flow banding is defined by recrystallized zones and lenses of devitrified		outcrops along Mill Creek just south of Mahogany Mountain in the Ochoco Reservoir 7.5' quadrangle. Flow textures range from planar flow banded to tightly folded horizontal to subvertical flow bands. Flow margins are marked by zones of black perlitic rhyolite. The base of the flow
e common along the periphery oped along scoriaceous zones	glass. Chemically, the rhyolite is peraluminous with 74.63 weight percent SiO ₂ ; 13.87 weight percent Al ₂ O ₃ ; and 3.89 weight percent K ₂ O (Sample 14; Table 1; Figure 1). The rhyolite is marked by high levels of barium (947 ppm Ba) and low levels of niobium (16.2 ppm Nb). The		in places is distinguished by folded flow bands of purple-white aphyric rhyolite. The surface of the flow weathers to tan to orange plates and angular chips. In thin section, the rhyolite is very
of well-rounded boulders and	rhyolite of Hash Rock is middle Eocene in age on the basis of a 40 Ar/ 39 Ar (plagioclase) radiometric age date determination of 39.35 ± 0.30 Ma in the Steins Pillar 7.5' quadrangle (McClaughry		fine-grained, flow banded, and plagioclase- and sanidine (microcline?)-phyric. Phenocrysts and spherulites are enclosed in a fine-grained, finely banded, red-brown, hypohyalline matrix. Flow-
ned, aphyric to plagioclase- sec. 30, T.12 S., R. 17 E.). The	and others, in prep). Rhyolite of Kidnap Springs (middle Eocene) – Purple to gray, flow banded, sanidine-		banding is defined by white, discreet spherulites to continuous spherulite bands up to 0.01 mm thick. Chemically, the unit is a rhyolite, with 75.32 weight percent SiO ₂ ; 13.31 weight percent AI_2O_4 ; 3.92 weight percent K_2O (Sample 2; Table 1; Figure 1). The rhyolite is marked by
crop; the outcrop is flanked by hyandesite is characterized by se crystal clots, and abundant,	and hornblende-phyric rhyolite porphyry intrusion that cuts units Tcal and Tcdp between School- house Creek on the east and the head of Dry Creek on the west. The unit includes an approxi-		comparatively low yttrium (47.1 ppm Y) and niobium (16.7 ppm Nb).
0.5 SiO_2 , 16.38 Al_2O_3 , 2.31 K_2O_3 , 0.00 contains elevated levels of	mately east-west trending dike exposed along McKay Creek in the center of sec. 7, T. 13 S., R. 17 E. The rhyolite forms low-lying, spire-like outcrops up to 10 m high with a well-developed vertical flow foliation. Locally, massive, vertically flow foliated rhyolite cores are encased by	Tcr	Undifferentiated Rhyolite (Eocene) – Tan to orange, massive, flow-banded, variably vesicular and brecciated, aphyric to sparsely porphyritic rhyolite flows, domes, and dikes that are unconformable upon and intrusive into unit Tcal. Flow textures range from planar flow banded to
is of similar lithologic textures, vest trending, columnar-jointed	devitrified, clast-supported breccia. The unit weathers to a brown-colored, grus-like mantle. In thin section, the rhyolite is sanidine- and hornblende-phyric with abundant, coarse-grained		tightly folded horizontal to vertical flow bands. The margins of flows and domes are marked by zones of banded black perlitic rhyolite, vitrophyre, and lythophasae. Outcrops generally show an
dium-grained, closed-textured,	cognate xenoliths. Both hornblende phenocrysts and the cores of sanidine crystals have been altered to sericite. Phenocrysts are encased in a microcrystalline to devitrified glass matrix.		increase in vesicularity near the top. The base to flows in places consists of folded flow bands of purple-white aphyric rhyolite. Rounded, and esite to dacite xenoliths up to 0.025 m across are
ric basalt and trachyandesite, s. The two en-echelon dikes	Cognate xenoliths are up to 0.15 m across at the outcrop scale and are composed of sanidine and hornblende. On the basis of geochemical analyses the unit is a rhyolite, with 70.65 – 70.99 weight percent SiO ₃ ; 14.71-15.26 weight percent Al ₂ O ₃ ; 0.44-0.45 TiO ₃ ; and 3.5-3.71 weight		abundant (5-10 percent by volume) in the large rhyolite mass exposed along Sealy Creek (Bingert, 1984). In thin section, the rhyolite is sparsely plagioclase- and pyroxene-phyric. Pheno- crysts are enclosed in a matrix of glass and intergrown quartz and alkali feldspar (Bingert, 1984).
are less than 30 m wide, are ked by red scoria. These dikes	percent SlO_2 , 14.71-15.20 weight percent R_2O_3 , 0.44-0.45 RO_2 , and 0.55.71 weight percent K_2O (Samples 8 and 20; Table 1; Figure 1). The rhyolite is marked by relatively high levels of barium (779-918 ppm Ba) and low levels of niobium (12.0-13.6 ppm Nb).		The matrix also includes equigranular, elongate lens-shaped, intergrowths of quartz, alkali feldspar, and biotite crystals that are parallel to flow banding. On the basis of geochemistry, the
ngs consists of gray trachyan- for unit Tma. This dike intrudes exceeds 100 m in width. Well-	Pumice-lithic tuff of Steins Pillar (middle Eocene) – White, pale yellow, and green,		unit is a rhyolite, with 72.61 to 76.11 weight percent SiO ₂ ; 12.51 to 14.40 weight percent AI_2O_3 ; and 2.78 to 3.82 weight percent K ₂ O (Samples 7, 23, 29 and 42; Table 1; Figure 1). The rhyolite is marked by high levels of barium (905 ppm Ba) and low levels of niobium (12.0 ppm Nb).
0.4 m across. Column orienta- vertical orientations near the	non-welded pumice-lithic tuff that is in high-angle contact with unit Tcal above Mill Creek in the southeast part of the map area. The unit is more than 300 m thick in the adjoining Steins Pillar 7.5' quadrangle (Waters, 1964). The tuff is massive, poorly-sorted, friable to indurated, lithic- and		Andesite (Eocene) – Blue to black, columnar- to platy-jointed, aphyric andesite that underlies
, scoria, and fluidal and bread-	pumice-rich and crystal-poor. Diffuse layering in the deposit is defined by alternating lithic-rich and pumice-rich layers. Lithics consist of aphyric to vesicular mafic fragments and flow-banded,	Tcau	the Rhyolite of Hash Rock (Tcrh) in the northern part of the map area and is disconformable across and inset into a variably dissected Eocene surface. North of McKay Creek, the unit is
paerial tuffaceous sedimentary	aphyric rhyolite. Mafic fragments are angular to plastically deformed and have a maximum size of 0.1 m across; clasts average 0.02-0.05 m across. Rhyolite lithics are angular, distinctly flow banded, and reach a maximum size of 0.37 m along a long axis; clasts average 0.1-0.15 m		relatively widespread, forming a platy armor on ridges. South of McKay Creek the unit is exposed in small isolated knobs characterized by red-oxidized soil zones and partially reworked, cobble- and boulder-rich flow surfaces. The unit includes a channel-filling, matrix-supported
Formation of Marsh (1875), into:	across. Pumice are white to pale-green, average 0.02-0.04 m in length, are feathered, stretched and moderately flattened, and are generally aligned in outcrop. In thin section, the tuff consists		conglomerate exposed southeast of Green Mountain in the SE ¼, sec. 16, T.13 S., R.17 E. The conglomerate is composed of boulder-sized clasts up to 1 m across of vesicular to closed-
	of banded pumice, angular mafic lithic fragments composed of a plagioclase and pyroxene groundmass, spherulitic, aphyric rhyolite clasts, and sparse, equigranular granite fragments.		textured andesite suspended in a fine- to medium-grained, silica-cemented, sandstone matrix. On the basis of geochemical analyses the unit consists of andesite, with $59.36 - 61.01$ weight
en, matrix-supported, indurated d rounded, low-elevation hills. ents up to 0.06 m across and	Anhedral, clear to white sanidine fragments are sparsely scattered in thin sections. Pumice, lithics, and crystals are enclosed in a devitrified glass and ash matrix. The unit includes a matrix- to clast-supported breccia composed of angular fragments of vitrophyre, that is exposed in the		percent SiO ₂ : 15.88-17.13 weight percent Al ₂ O ₃ : 0.88-1.08 TiO ₂ : and 1.05-1.25 weight percent K_2O (Samples 12 and 30; Table 1; Figure 1). Large landslide deposits (Qls) are commonly preserved downslope of the basal contact of unit Tcau flows. The andesite is middle Eocene in
ents as much as 0.1 m across. sanidine feldspar crystals. On	north $\frac{1}{2}$ of sec. 26, T. 13 S., R.17 E. On the basis of geochemical analysis, the pumice-tuff is peraluminous with 75.08 weight percent SiO ₂ ; 13.53 weight percent Al ₂ O ₃ ; and 4.31 weight		age on the basis of a 40 Ar/ 39 Ar (plagioclase) radiometric age date determination of 41.50 ± 0.48 Ma in the Dutchman Creek 7.5' quadrangle (McClaughry and others, in prep).
d Ferns (2006a), the unit is a AI_2O_3 , and 1.64 weight percent	percent K_2O (Sample 43; Table 1; Figure 1). Marked by moderate levels of barium (657 ppm Ba) and low levels of niobium (13.3 ppm Nb). The tuff is interpreted as intracaldera-fill to the Wildcat Mountain caldera. Stratigraphic position of the tuff of Steins Pillar above unit Tcau andesite	Tcid	Porphyritic dacite and andesite intrusive rocks (Eocene) – Plagioclase- and hornblende-phyric dikes and irregularly shaped stocks. The unit includes a belt of northwest
om Zr) and yttrium (96 ppm Y). n of the map area). The section ct with and onlaps dacite and	$(41.50 \pm 0.48 \text{ Ma})$ and beneath the rhyolite of Hash Rock (39.35 ± 0.30 Ma) indicates the tuff may be temporally correlative with the basal member A ash flow tuff identified in the John Day		trending dikes and plugs that intrude aphyric unit Tcal flows between Lemon Creek and McKay Creek. The unit also includes a small stock at the north end of Johnson Creek. Northwest
fill facies to the Crooked River ive with the tuff of Smith Rock	Formation (Peck, 1964; Robinson, 1975; Swanson and Robinson, 1968). The member A tuff has a radiometric age of 39.22 ± 0.03 Ma (near Clarno), 39.72 ± 0.03 Ma (Painted Hills ~20 km called a finite sector of the sector of t		trending dikes are typically blue-gray to dark gray on fresh surfaces, massive to platy jointed, and are layered with alternating fine- and coarse-grained bands. Rounded, crystalline plutonic
sely welded, pumice-lithic tuff	northeast of the map area) (single crystal Ar ⁴⁰ /Ar ³⁹ ; Bestland and Retallack, 1994a, 1994b; Retallack and others, 2000) and 39.17 ± 0.15 (near Ashwood) single crystal Ar ⁴⁰ /Ar ³⁹ ; Smith and others, 1998).		xenoliths up to 0.04 m across are abundant. In thin section, these dikes consist of seriate- textured medium-grained, plagioclase-, orthopyroxene-, clinopyroxene-, biotite-, horneblende- phyric dacite and medium-grained, plagioclase-, clinopyroxene-, orthopyroxene-phyric and
ted to be equivalent to the Tuff quadrangle (McClaughry and	Rhyolite breccia pipes and dikes (middle Eocene) – Bleached white to orange,		glomeroporphyritic andesite. Phenocrysts and glomerocrysts are enclosed in a fine-grained, equigranular groundmass composed of feldpsar microlites and intergranular, opaque iron-oxide
15 m thick, and is moderately consist of fresh, pumice, lithic, bs that break into large slabs.	massive, monolithic, clast-supported rhyolite breccia that forms east-west elongate masses intrusive into unit Tcal in sec. 24, T. 13 S., R. 17 E. Clasts are angular and consist of vesicular, aphyric to sanidine-phyric rhyolite that have centimeter scale alteration halos. The clasts have a		minerals. The Johnson Creek intrusive body is a blue-gray mass that forms a crudely elliptical stock measuring about 1,500 m by 1,000 m. The intrusion is plagioclase-phyric and contains white, medium-grained, holocrystalline xenoliths up to 8 m across. In thin section, the Johnson
0.06 m long that are aligned s, and consist of gray and pink	maximum long axis of 0.3 m across; clasts average 0.02-0.04 m across. In thin section, breccia clasts consist of angular to subround, devitrified, altered sanidine-phyric rhyolite fragments.		Creek intrusion contains aligned, euhedral to subhedral, strongly zoned plagioclase (1 mm across) and relict hornblende (0.5 mm across) phenocrysts in a seriate groundmass of similar
ne tuff contains white to gray green clinopyroxene (augite)	Clasts typically have irregular, serated margins and are supported in a red to pink, fine-grained, altered matrix that is the equivalent of the clasts. Both the matrix and the margins of clasts show		composition. Xenoliths in the Johnson Creek intrusion are diorite composed mostly of interlock- ing euhedral plagioclase and relict hornblende crystals with minor amounts of quartz crystals. Hornblende is largely replaced by opague minerals, while the guartz crystals have been recrys-
ash-rich matrix. Glass shards ned or fused to one another. s characterized by pink-red to	dissolution textures. The unit displays pervasive sulfide alteration and minor quartz veining. The breccia includes 0.5 m wide, finger-like dikes oriented N15°W, 80°NE, that intrude unit Tcal in the north half of sec. 24, T. 13 S., R. 17 E. These dikes are not brecciated; both the intrusive rhyolite		tallized to a mortar texture. The matrix is replaced by a mixture of feldspar, quartz, and very fine- grained sericite and calcite. On the basis of geochemical analyses, the unit includes high silica
nd gray pumice up to 0.01 m that contain contorted vertical	and host unit Tcal are altered along the contact, weathering to a white and orange powder. Andesite and dacite breccia pipes and dikes (middle Eocene) – Purple to green,		andesite and dacite with 61.19 to 63.25 weight percent SiO ₂ ; 15.82 to 16.85 weight percent Al ₂ O ₃ , 0.83 to 0.94 weight percent TiO ₂ ; and 1.19 to 1.53 weight percent K ₂ O (Samples 5, 9, 10 and 19;
eter; some cavities are quartz- lythophysal zones. Based on it is a rhyolite tuff, with 76.17-	moderately matrix-supported, monolithologic breccia that forms east-west elongate masses that are exposed along the margin of Tcrk rhyolites and intrusive into unit Tcal (sec. 23, 26, T. 13 S.,		Table 1; Figure 1; McClaughry and Ferns, 2006b). Equivalent to unit Tca of Waters and Vaughan (1968) and unit Tcmi of Swanson (1969).
81-2.22 weight percent FeO*; high levels of barium (539-720	R. 17 E.). The unit forms resistant spire-like outcrops that weather to a dark gray with sporadic red-oxidized zones. Locally, anastomosing breccia zones enclose coherent andesite and dacite; the breccia is composed of angular andesite and dacite clasts up to 0.05 m in diameter that are	Tcal	Andesite and dacite lava flows (Eocene) – Gray to black, purple-weathering, fine- grained, porphyritic, aphyric, plagioclase-phyric, and plagioclase-hornblende phyric andesite and dacite flows and domes that form thick homogeneous masses throughout the map area. The unit
.0 ppm Nb). On the basis of onsidered to represent outflow	encased in a dark purple gray silicified matrix. In thin section, breccia clasts consist of angular to subangular fragments of unaltered, fine-grained, equigranular, moderately trachytic, aphyric,		is commonly platy-jointed to locally columnar-jointed and weathers to form steep, rounded hills armored by angular rock chips. In some locations, the unit consists of complexly intertonguing
Sa,c; 2007a). An Oligocene age ith intracaldera-fill tuff (Tjt).	andesite and dacite composed of plagioclase, clinopyroxene, and orthopyroxene. Clasts margins are typically smooth to moderately serated; the boundaries between clasts and matrix		flow-on-flow sequences of thick platy lava flows. The margins of individual flows are defined by purple to brown, basal and marginal autobreccia deposits. Topographic breaks between
rple to light brown, indurated, rlies Clarno Formation rocks at ly poorly exposed (weathers to	is sharp. Jigsaw and crackle breccia textures are locally pervasive. The matrix is distinctly green-colored and is composed of a nearly bimodal distribution of poorly sorted rock fragments (~ 0.1-0.2 mm across on average) and very fine material (devitrified ash and/or glass). The		individual lava flows are commonly marked by brick red, reddish-orange and maroon clay soils. Lithologic and chemical similarity across breaks precludes the mapping of individual flows. In thin section, the unit consists of very fine-grained to fine-grained, closed-textured, aphyric, plagio-
where the tuff forms prominent ase, quartz, biotite, and amphi-	matrix is composed of grains that are equivalent to the gravel-sized clasts and highly angular crystal fragments of white, alkali-feldspar, plagioclase, and pyroxene. The matrix is approxi-		clase-, pyroxene-, and microcline-phyric, and glomeroporphyritic andesite and dacite. Thin sections also contain embayed, anhedral quartz rimmed by clinopyroxene grains and broken,
d crystalline rock fragments. ine a well-developed eutaxitic	mately 40 percent lithic grains, 10 percent free alkali-feldspar crystals, and 50 percent fine to very fine, altered green ash. Crystals in the matrix are variably altered to sericite and chlorite(?); alteration is overall more prevalent in the matrix that the clasts.		twinned plagioclase crystals that may be xenocrysts. Phenocrysts are enclosed in a fine-grained, hypohyalline to equigranular hypocrystalline, variably trachytic groundmass of plagioclase and purportidal to restongular iron evide
ne-grained matrix composed of s abundant lythophasae (up to nasae are filled by secondary	Dacite and rhyolite of Brennan Palisades (Eocene) – Purple to tan-gray, columnar-		pyroxene, as well as intergranular pyroxene, glass, and pyramidal to rectangular iron-oxide minerals. The unit ranges from andesite to dacite, with 59.17 to 63.48 weight percent SiO_2 ; 15.94 to 17.16 weight percent Al_2O_3 ; 0.82 to 1.20 weight percent TiO_3 ; and 0.99 to 1.92 weight percent
lored, sparsely feldspar-phyric ay be as much as 100 m thick.	jointed, layered, feldspar-phyric compound dacite to rhyolite intrusion that is nonconformable into unit Tcal at Brennan Palisades and along Schoolhouse Creek. The unit contains abundant xenoliths and/or xenocrysts. Layering in the Brennan Palisades intrusion is defined by alternat-		K O (Samples 4, 6, 21, 24, 25 and 26; Table 1; Figure 1). Equivalent to the Clarno Formation of Merriam (1901). On the basis of intraflow contacts and intervening weathering zones, the unit is
ent SiO ₂ , 12.40 to 12.67 weight 11 and 35; Table 1; Figure 1). derate levels of niobium (64 to	ing vesicle-rich and massive, vesicle-poor bands. The bands are typically 0.02-0.05 m thick, distinctly segregated, and laterally continuous over tens of meters. Locally bands show well-		interpreted to be composed of several different aged successions of lithologically similar appear- ing lava flows. Includes a mass of iron-stained, aphyric andesite exposed along the east edge of the map area, between Dry Creek and Mill Creek, that is interpreted as hydrothermally altered
n unit Tjtw indicate that this tuff cene Crooked River caldera.	developed kink folds and are separated by coarse breccia layers and lensoid, boudin-like features up 0.3 m thick and 0.6 m long. At Brennan Palisades, the layering dips to the west, with		basement rocks to the Wildcat Mountain caldera.
prrelation of the tuff as outflow rn part of the map area.	the dip angle increasing to the east-southeast; on the east, the unit becomes more massive. The unit weathers to bulbous hoodoo forms with a brown-colored, grus-like mantle. Chemically, the unit is a dacite to rhyolite with 67.65-72.61 weight percent SiO,; 14.25-15.42 weight percent	Tcdp	Porphyritic andesite and dacite (Eocene) – Domal masses of black to gray, massive, bulbous to spine-like, flow-banded andesite to dacite porphyry. Includes spine-like, vertically flow banded masses and bulbous, horoziontally-flow banded masses. Forms two exposure belts,
, and shallow intrusions, dacite	Al_2O_3 ; 0.41-0.73 weight percent TiO ₂ ; and 2.59-3.69 weight percent K ₂ O (Sample 3 and 44; Table 1; Figure 1). The dacite is marked by elevated levels of barium (667-772 ppm Ba) and low levels		banded masses and bulbous, horoziontally-flow banded masses. Forms two exposure belts, one in the eastern part of the map area near Lemon Creek and a second in the northern part of the map area. In thin section, the dacite contains blocky, equant phenocrysts of hornblende (0.5
t Mountain Caldera complex, o Formation of Merriam (1901)	of niobium (11.8-15.8 ppm Nb). Plagioclase-hornblende-phyric andesite and dacite (Eocene) – Dark gray to yellow		mm), strongly zoned plagioclase (1.5 mm), and hypersthene (0.5 mm) set in a fresh appearing glassy groundmass. Glomerocrysts of hornblende, plagioclase, and sub-ophitic pyroxene are
х , , , , , , , , , , , , , , , , , , ,	gray, medium to very coarse-grained, plagioclase- and hornblende-phyric andesite and dacite, and dacite porphyry domes that are nonconformable into unit Tcal along Lofton and Bogue		also present. On the basis of geochemical analyses from this map area and analyses from the adjoining Ochoco Reservoir 7.5' quadrangle (McClaughry and Ferns, 2006b), the porphyry consists largely of peraluminous andesite to high-silica dacite, with a range of range of chemical
black, fine- to medium-grained,	Creeks in the northwest part of the map area. Outcrops are generally massive (locally spire forming at Cougar Rock), deeply weathered, covered by grus-like soils. Internally, the unit is		abundances from 58.21 to 67.76 weight percent SiO ₂ ; 13.54 to 17.83 weight percent Al ₂ O ₃ ; 0.48 to 0.90 weight percent TiO ₂ ; and 1.32 to 2.68 weight percent K ₂ O (Sample 17, Table 1; Figure 1).
, exposed in an east to west is disconformable across and / platy-jointed and form muted	finely banded by alternating coarse-grained and fine-grained layers. In thin section, the unit is medium- to coarse-grained, seriate textured, and plagioclase-, hornblende-, and alkali-feldspar- phyric. Minor constituents include rounded quartz phenocrysts and large cognate xenoliths of		A ~2 x 3 m granite xenolith is exposed in the porphyry southeast of Bottleneck Spring in the NW¼, NE ¼, sec. 2, T. 13 S., R. 16 E. The xenolith has a typical granite geochemical composi-
with red-oxidized soils. In thin ral to subhedral, etched and	plagioclase and hornblende more than 0.01 m in diameter. Phenocrysts are enclosed in a matrix of equigranular plagioclase and hornblende and variably devitrified glass. On the basis of		tion with 73.67 weight percent SiO ₂ ; 0.35 weight percent Al ₂ O ₃ ; 0.35 weight percent TiO ₂ ; and 3.89 weight percent K ₂ O (Sample 31, Table 1; Figure 1). In thin section the granite is medium- grained, equigranular, and holocrystalline containing anhedral crystals of plagioclase (70 modal
nm in length. Plagioclase are d feldpsar phenocryst up to 1.2	geochemical analyses (Bingert, 1984), the unit ranges from an andesite to high silica dacite, with 62.07 to 70.61 weight percent SiO ₂ : 13.54 to 16.57 weight percent Al ₂ O ₃ ; and 0.04 to 3.52 weight		percent) and quartz (25 modal percent). Sparse, light brown, biotite tablets (5 modal percent) with zircon inclusions occur as intergranular components. A distinct consertal texture is

	Trace elements (parts per million)																										
MnO	CaO	MgO	K ₂ O	Na ₂ O	P ₂ O ₅	Ni	Cr	Sc	V	Ва	Rb	Sr		Y						La	Ce	Th	U	Co	LOI	Fe ₂ O ₃	FeO
0.12	6.36	3.22	1.13	3.59	0.20	24	45	18	126	529	34.5	414	195	23.3	10.9	17.7	37	71	6	21	38	3.0	1.4	17	1.80	1.12	4.38
0.02	0.78	0.00	3.92	4.40	0.03	2	1	7	9	961	128.8	61	301	47.1	16.7	16.0	4	52	13	41	72	15.0	5.1	0	1.14	0.42	1.44
0.07	3.89	1.61	2.59	3.80	0.18	18	23	12	84	667	79.6	223	209	24.2	11.8	16.4	33	58	8	26	54	9.1	3.3	8	2.81	3.10	0.76
0.11	5.94	2.39	1.42	3.80	0.21	15	27	16	122	521	39.6	406	187	21.6	10.8	17.6	36	67	7	21	38	4.0	1.9	17	1.71	2.49	2.78
0.08	5.48	2.84	1.44	3.33	0.25	38	78	18	119	441	30.1	305	220	22.5	13.4	18.4	59	83	6	22	50	4.7	1.2	21	3.87	5.27	1.00
0.14	6.02	3.01	1.37	3.44	0.41	37	79	21	123	457	33.0	307	294	32.2	21.0	20.0	50	86	6	25	63	4.5	0.0	24	1.88	3.40	3.83
0.03	1.11	0.04	5.12	2.98	0.06	4	5	5	23	905	167.3	74	138	23.5	12.0	13.6	2	29	8	27	50	17.7	4.6	0	0.85	1.51	0.26
0.06	2.38	0.26	3.50	3.96	0.10	12	13	8	50	918	116.6	168	233	20.9	12.0	16.6	21	47	8	35	63	11.7	4.1	3	2.48	2.55	0.36
0.13	5.94	3.21	1.39	3.47	0.25	35	80	17	135	537	33.5	313	216	21.8	12.6	18.2	58	75	6	24	50	5.1	0.0	18	4.53	5.07	1.62
0.09	5.69	2.31	1.53	3.55	0.24	25	31				26.4	328		24.7				83	6	24	49		1.3		3.49	6.04	0.32
0.04	0.28	0.03	4.02	4.28	0.05	0	0	1			128.9	45		121.9				164	13	83	162	16.8	5.1	1	1.04	1.97	0.35
0.16	6.60	3.60	1.05	3.46	0.43	40	79	19	134	437	25.1	332	275	32.2	22.4	19.9	93	100	6	24	61	2.9	1.5	26	1.17	1.61	6.05
0.06	3.53	0.72	2.12	4.47	0.14	10	14	11	52	715	60.6	370	202	23.3	11.3	16.7	27	53	9	26	54	6.0	1.6	5	2.02	2.84	0.64
0.01	0.72	0.00	3.89	4.26	0.05	2	0	6	14	947	131.6	58	316	55.4	16.2	16.6	6	55	12	56	55	16.2	4.0	0	1.27	1.91	0.38
0.09	5.01	1.72	2.37	3.58	0.22	13	13	14	128	644	72.5	288	210	26.9	12.5	17.9	38	70	6	27	60	8.0	1.8	14	2.81	1.33	4.17
0.17	10.08	7.70	0.57	2.39	0.23	48	105	24	202	197	8.7	293	115	25.1	10.3	18.8	29	95	5	13	22	1.8	0.6	42	2.19	2.56	7.68
0.11	7.64	4.02	1.32	3.28	0.18	73	91	20	136	341	43.8	383	148	20.8	9.2	17.4	54	66	4	16	31	4.9	0.7	23	1.59	3.23	2.92
0.17	9.02	6.97	0.85	3.08	0.38	67	56	26	243	291	20.8	384	143	34.8	11.0	19.1	55	93	5	15	31	2.5	0.0	43	1.90	3.95	6.75
0.13	6.47	3.56	1.19	3.24	0.21	35	76	18	132	487	36.7	334	219	24.6	12.5	17.9	43	78	6	26	53	5.0	1.9	20	1.80	1.93	4.31
0.07	2.41	0.87	3.71	3.74	0.14	7	17	9	34	779	138.1	154	217	29.7	13.6	16.7	10	49	12	29	65	13.8	3.8	3	2.33	2.89	0.25
0.17	6.47	3.17	1.51	3.41	0.42	43	79	20	145	450	37.9	347	269	31.1	20.3	18.8	63	94	6	25	52	3.8	0.8	24	1.84	4.11	3.76
0.17	6.16	2.92	1.59	3.42	0.37	37	77	20	125	463	46.6	305	284	32.7	20.4	19.0	72	94	5	26	57	3.9	0.0	23	1.54	3.92	3.52
0.00	0.87	0.00	3.82	4.33	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	8.29	4.22	0.99	3.26	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		nd	nd	nd		nd	nd	nd	nd
0.00	7.06	4.64	1.76	4.70	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	4.94	3.13	1.92	3.99	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	3.70	1.11	2.53	3.24	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	3.94	1.62	2.49	3.04	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	1.82	0.30	3.61	4.20	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	6.88	3.24	1.25	3.55	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.01	1.59	0.24	3.89	4.21	0.08	3	10	6	28	907	104.4	124	347	23.8	13.2	16.9	18	23	15	28	69	14.9	2.0	0	1.78	1.54	0.24
0.00	6.10	3.52	1.83	3.31	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	5.35	3.50	2.39	3.25	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	10.80	9.48	0.40	2.37	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.09	0.81	0.06	3.74	4.26	0.08	1	0	7	16	1144	116.9	76	596	97.2	64.2	25.5	0	157	9	56	123	15.7	5.2	2	1.62	4.00	0.33
0.08	7.90	3.07	2.31	4.60	0.87	25	17		147		12.5								6	22	99			18	0.62	4.34	1.54
0.00	8.68	5.01	0.78	3.07			75		198		30.3			27.4								3.7			2.10	2.63	5.60
					0.30	83																					
0.16	10.65	7.97	0.46	2.39	0.18		409	36		141	5.2	553		21.1				84	4	13	21		0.7	45	0.54	6.67	3.56
0.00	3.73	1.91	2.68	3.06	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	4.48	0.04	1.79	4.35	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	4.12	3.23	2.24	4.44	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.00	2.31	0.20	2.78	4.50	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
0.02	2.87	1.00	4.31	0.72	0.04	3	13	7	26	657	125.9	289	111	19	13.3	12.6	5	35	6	23	40	13.6	3.0	0	8.68	1.43	0.52
0.05	1.51	0.12	3.69	4.25	0.10	1	3	6	25	772	131.1	127	281	26	15.8	16.8	10	58	10	31	60	12.0	4.3	1.00	1.21	2.67	0.28

percent K₂O (Samples 27, 28, 32, 33, 39, 40 and 41; Table 1; Figure 1).

REFERENCES

developed in the thin section, where quartz crystals are intergrown along the margins of plagio-

clase crystals. On the basis of outcrop distribution, unit Tcdp is interpreted as eroded dome

complexes or shallow, subvolcanic intrusive masses.

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Preliminary Geologic Map of the Hensley Butte and Salt Butte 7.5' Quadrangles, Crook County, Oregon

By M.L. Ferns and J.D. McClaughry

Bestland, E. A., and Retallack, 1994a, Geology of the Clarno Unit, John Day Fossil Beds National Monument: National Parks Service Report on Contract CX900-1-10009, 202 p. Bestland, E. A., and Retallack, 1994b, Geology of the Painted Hills Unit, John Day Fossil Beds National Monument: National Parks Service Report on Contract CX900-1-10009, 260 p., Bingert, N. J., 1984, Geology of the northeast one-quarter of the Prineville Quadrangle, North-Central Oregon: Corvallis, Oreg., Oregon State University masters thesis, 141 p, map scale 1:24,000. Brooks, H. C., 1963, Quicksilver in Oregon: Oregon Department of Geology and Mineral Industries Bulletin 55, 223 p. Fiebelkorn, R.B., Walker , G.W., MacLeod, N.S., McKee, E.H., and Smith, J.G., 1983, Index to K-Ar age determinations for the state of Oregon: Isochron/West, no. 37, p. 3-60. Gradstein, F.M., Ogg, J.G., and Smith, A.G., Agterberg, F.P., Bleeker, W., Cooper, R.A., Davydov, V., Gibbard, P., Hinnov, A., House, M.R., Lourens, L., Luterbacher, H.P., McArthur, J., Melchin, M.J., Robb, L.J., Shergold, J., Villeneuve, M., Wardlaw, B.R., Ali, J., Brinkhuis, H., Hilgen, F.J., Hooker, J., Howarth, R.J., Knoll, A.H., Laskar, J., Monechi, S., Plumb, K.A., Powell, J., Raffi, I., Röhl, U., Sadler, P., Sanfilippo, A., Schmitz, B., Shackleton, N.J., Shields, G.A., Strauss, H., Van Dam, J., van Kolfschoten, T., Veizer, J., and Wilson, D., 2004, A Geologic Time Scale 2004: Cambridge Universit Press, 589 p. Le Bas, M.J., Le Maitre, R.W., Streckeisen, A., and Zanettin, B., 1986, Journal of Petrology, v. 27, part 3, p. 745-750. Le Maitre, R.W., Bateman, P., Dudek, A., Keller, J., Lemeyre, J., Le Bas, M.J., Sabine, P.A., Schmid, R., Sorenson, H., Streckeisen, A., Wooley, A.R., and Zanettin, B., 1989, A classification of igneous rocks and glossary of terms: Oxford, Blackwell, 193 p. Marsh, O.C., 1875, Ancient lake basins of the Rocky Mountains region: American Journal of Science, 3d ser., v. 9, p. 49 McClaughry, J. D., and Ferns, M.L., 2006a, Preliminary Geologic Map of the Prineville 7.5' Quadrangle, Crook County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Map O-06-22, scale 1:24,000. McClaughry, J. D., and Ferns, M.L., 2006b, Preliminary Geologic Map of the Ochoco Reservoir 7.5' Quadrangle, Crook County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Map O-06-23, scale 1:24,000. McClaughry, J. D., and Ferns, M.L., 2006c, Field Trip Guide to the Geology of the Lower Crooked River Basin, Redmond and Prineville areas, Oregon: Oregon Department of Geology and Mineral Industries, Oregon Geology, Vol. 67, No. 1, McClaughry, J. D., and Ferns, M.L., 2007a, The Crooked River Caldera: Identification of an early Oligocene eruptive center in the John Day Formation of central Oregon: Geological Society of America Abstracts with Programs, Vol. 39, no. 4, p. 10. McClaughry, J. D., and Ferns, M.L., 2007b, Neogene Basalt Flow Stratigraphy near Prineville, Oregon: Interaction with the Ancestral Crooked River: Geological Society of America Abstracts with Programs, Vol. 39, no. 4, p. 72. McClaughry, J. D., and Ferns, M.L., 2007c, Preliminary Geologic Map of the Eagle Rock 7.5' Quadrangle, Crook County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Map O-07-10, scale 1:24,000. McClaughry, J. D., and Ferns, M.L., 2007d, Preliminary Geologic Map of the Stearns Butte 7.5' Quadrangle, Crook County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Map O-07-12, scale 1:24,000. McClaughry, J.D., Ferns, M.L., and Gordon, C.L., in prep, Geologic Map of the Wildcat Mountain Caldera, Crook County, Oregon: Oregon Department of Geology and Mineral Industries, scale 1:24,000. Merriam, J.C., 1901, A contribution to the geology of the John Day Basin [Oregon]" California Univ. Pubs., Dept. Geology Bull., v. 2, no. 9, p. 269 – 314. Noblett, J.B., 1981, Subduction-related origin of the volcanic rocks of the Eocene Clarno Formation near Cherry Creek, Oregon: Oregon Department of Geology and Mineral Industries, Oregon Geology Vol. 43, No. 7, p. 91 – 99. Peck, D. L., 1964, Geologic reconnaissance of the Antelope-Ashwood area of north-central Oregon, with emphasis on the John Day Formation of late Oligocene and early Miocene age: U.S. Geological Survey Bulletin 1161-D, 26 p. Retallack, G.J., Bestland, E.A., and Fremd, T.J., 2000, Eocene and Oligocene Paleosols of Central Oregon: Geological Society of America Special Paper 344, 192 p. Robinson, J.W., and Price, D., 1963, Ground water in the Prineville area, Crook County, Oregon: U.S. Geological Survey Water-Supply Paper 1619-P, P1 – P49. Robinson, P.T., 1975, Reconnaissance geologic map of the John Day Formation in the southwestern part of the Blue Mountains and adjacent areas, north-cental Oregon: U.S. Geological Survey Miscellaneous Investigations Series Map I-872, scale 1:125,000. Robinson, P.T., and Stensland, D.H., 1979, Geologic map of the Smith Rock area, Jefferson, Deschutes, and Crook Counties, Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1142, scale 1:48,000. Robinson, P.T., Walker, G.W., and McKee. E.H., 1990, Eocene(?), Oligocene and lower Miocene rocks of the Blue Mountains region, in Walker, G.W., ed., Geology of the Blue Mountains region of Oregon, Idaho, and Washington: U.S. Geological Survey Professional Paper 1437, p. 29-62. Smith, G.A., Manchester, S.R., McIntosh, W., and Contrey, R.M., 1998, Late Eocene-early Oligocene tectonism, volcanism, and floristic change near Gray butte, central Oregon: Geological Society of America Bulletin, v. 110, p. 759 Swanson, D.A., and Robinson, P.T., 1968, Base of the John Day Formation in and near the Horse Heaven Mining District, North-Central Oregon: U.S. Geological Survey Professional Paper 600-D, p. D154-D161. Swanson, D.A., 1969, Reconnaissance geologic map of the east half of the Bend quadrangle, Crook, Wheeler, Jefferson, Wasco, and Deschutes Counties, Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-568, scale 1:250,000 Walker, G.W. and Robinson, P.T., 1990, Paleocene(?), Eocene, and Oligocene(?) rocks of the Blue Mountains Region: in Walker, G.W., ed., Geology of the Blue Mountains Region of Oregon, Idaho, and Washington, Cenozoic Geology of the Blue Mountains Region: U.S. Geological Survey Professional Paper 1437, p. 13 – 27. Waters, A.C., 1964, Steins Pillar area, central Oregon: Oregon Geology and Mineral Industries, Ore Bin, Vol. 28, no. 8, p. 137 – 144.