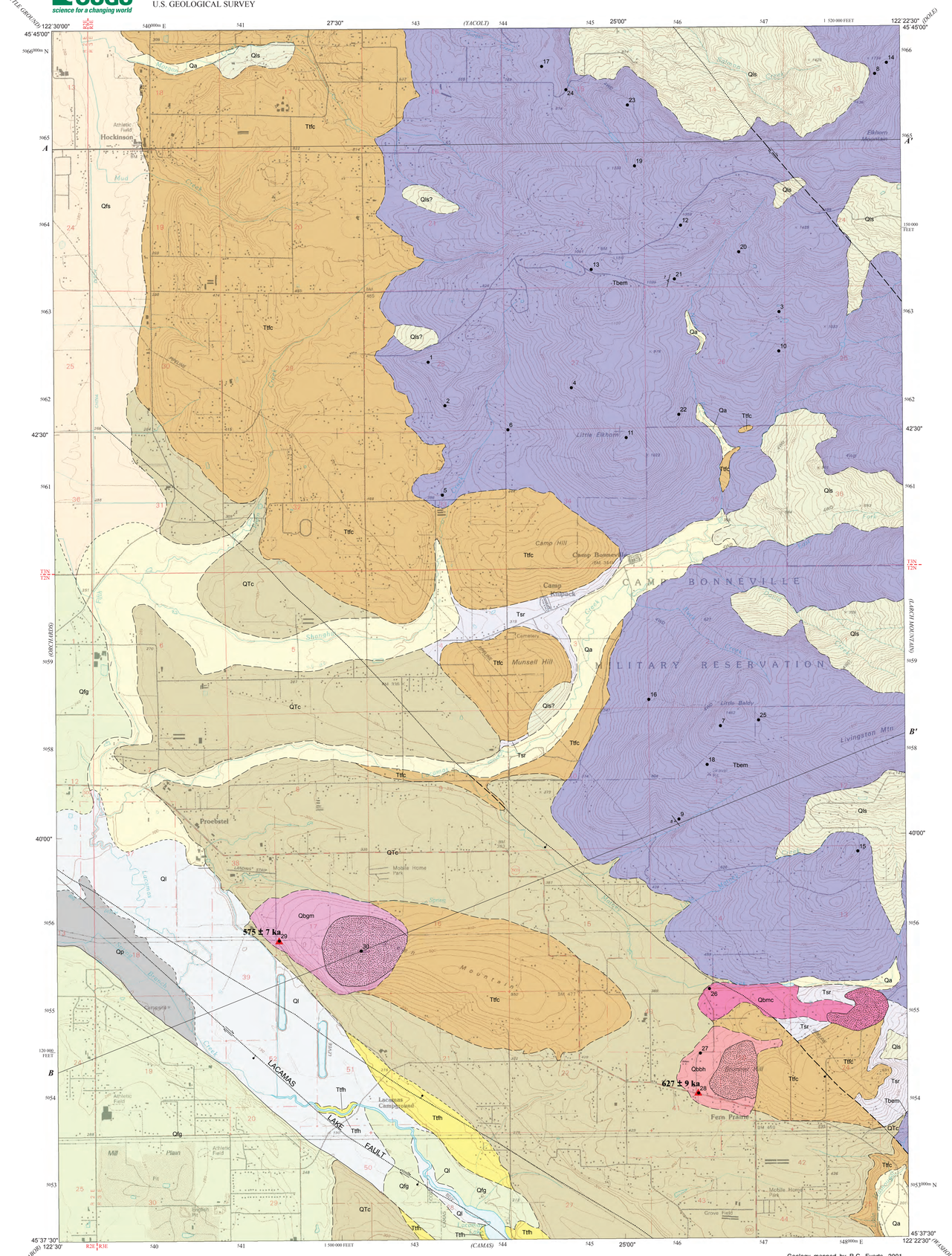
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SCIENTIFIC INVESTIGATIONS MAP 2924
Pamphlet accompanies map



Base from U.S. Geological Survey, Lacamas Creek, 1990.
Universal Transverse Mercator projection, zone 10

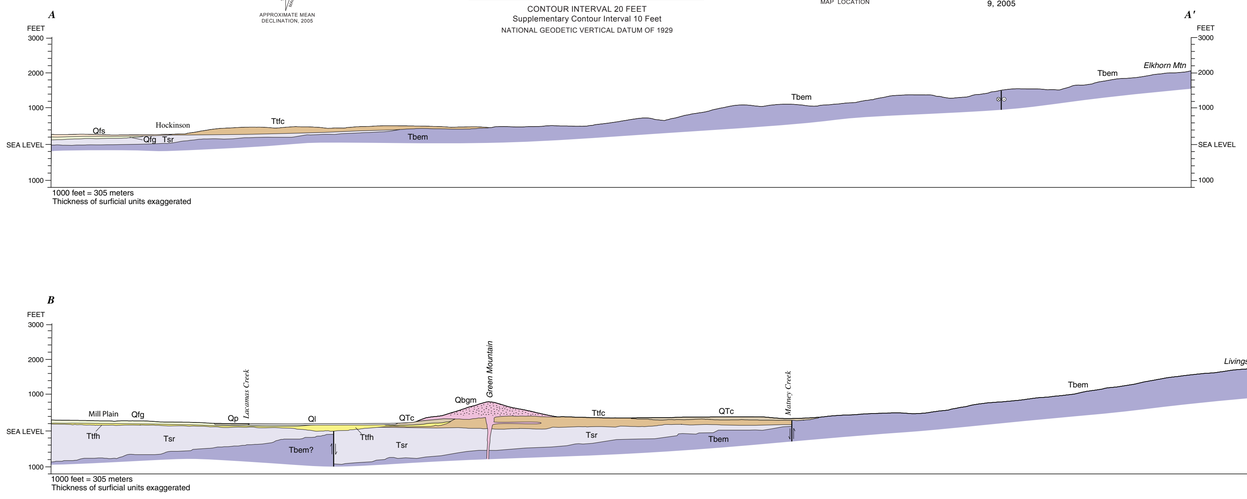
17°
TRUE NORTH
APPROXIMATE MEAN DECLINATION, 2005
MAGNETIC NORTH

SCALE 1:24 000
1 0 1 MILE
1 0 1 KILOMETER

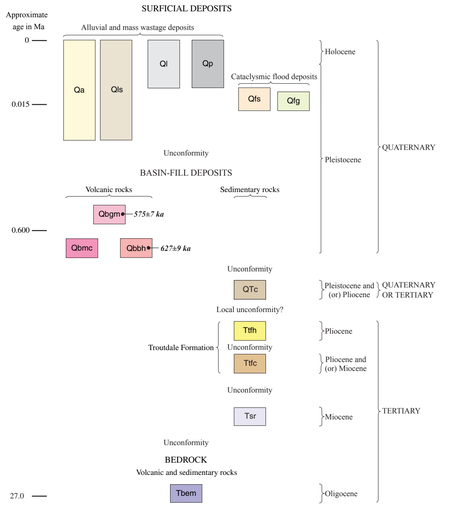
CONTOUR INTERVAL 20 FEET
Supplementary Contour Interval 10 Feet
NATIONAL GEODETIC VERTICAL DATUM OF 1929

WASHINGTON
MAP LOCATION

Geology mapped by R.C. Evarts, 2001-2003
Digital database by P.A. Dinterman
Edited by Theresa Iki
Manuscript approved for publication May 9, 2005



CORRELATION OF MAP UNITS*



*Age of epoch boundaries from time scale of Berggren and others (1995). $^{40}Ar/^{39}Ar$ ages shown from table 2

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Alluvial and mass wastage deposits

Qa **Alluvium (Holocene and Pleistocene)**—Thin deposits of unconsolidated silt, sand, and gravel along creeks

Qls **Landslide deposits (Holocene and Pleistocene)**—Diamictons of angular bedrock and (or) surficial material transported down slope en masse. Chiefly deep-seated, semi-coherent slumps and internally disrupted rockslide, earthflow, and debris-flow deposits. Many mapped slides head at arcuate scars and exhibit subhorizontal tops, bulbous toes, and hummocky, poorly drained surfaces. Large slides in eastern part of map area generated by failure of deeply weathered volcaniclastic interbeds within flow-dominated bedrock (Tbem); smaller slides developed in weakly consolidated Neogene sedimentary rocks (Tsr, Ttfc)

Ql **Lake deposits (Holocene and Pleistocene)**—Unconsolidated black to gray silt, mud, and organic debris underlying wide flat valley of Lacamas Creek northwest of Lacamas Lake; grade into fine-grained alluvium (Qa) and peat deposits (Qp); overlie gravel probably deposited by cataclysmic floods (Qfg) and hyaloclastic sedimentary rocks (Ttfh); lower part may include Missoula-flood slack-water deposits (Qfs). Sparse well logs indicate deposit is less than 5 m thick

Qp **Peat (Holocene and Pleistocene)**—Dark-brown to olive-green fibrous peat and organic-rich mud (Rigg, 1958; Trimble, 1963). Less than 5 m thick; grades southeastward into organic rich lake beds (Ql); overlies gravel probably deposited by cataclysmic floods (Qfg). Distribution is based largely on Clark County soil survey (McGee, 1972)

Cataclysmic-flood deposits (Pleistocene)—Sediment deposited by colossal glacier-outburst floods caused by repeated failures of ice dam at Pleistocene Lake Missoula in Montana, (Bretz, 1925, 1959; Bretz and others, 1956; Trimble, 1963; Allison, 1978; Baker and Bunker, 1985; Waitt, 1985, 1994, 1996; Atwater, 1986; O'Connor and Baker, 1992; Benito and O'Connor, 2003). Floods exiting Columbia River Gorge spread out in Portland Basin and deposited coarse load in series of large bars and plains, the Portland delta of Bretz (1925). Hydraulically dammed floodwaters temporarily ponded in Portland Basin and deposited suspended sediment load (Trimble, 1963). Radiocarbon and tephrochronologic data from outside the map area indicate depositional ages between about 17,000 and 13,000 ^{14}C years B.P. (Waitt, 1985, 1994; Atwater, 1986; Benito and O'Connor, 2003; Clague and others, 2003). Coarse bedload deposits and fine slack-water deposits mapped separately

Qfs **Sand and silt facies**—Unconsolidated deposits of silt, sand, and minor clay mantling surfaces below about 300 ft (90 m) elevation in northwest part of quadrangle. Rarely exposed; distribution inferred largely from well logs, which indicate thickness of unit in map area ranges from 0 to about 15 m. Composed largely of quartz, feldspar, and muscovite, indicating deposition by Columbia River rather than by local streams. Consists of sediment deposited by rapidly decelerating and temporarily ponded floodwaters

Qfg **Gravel facies**—Unconsolidated bouldery pebble to cobble gravel in southwestern part of map area. Underlies Lacamas Creek valley northwest of Lacamas Lake and Mill Plain, part of a large bar formed in the lee of Prune Hill to the south (Waitt, 1994). Equivalent to the gravelly phase of lacustrine deposits of Trimble (1963). Poorly sorted; clast-supported; contains well-rounded to subangular clasts as large as 2.5 m diameter; some open-work gravel, but most contains matrix of basaltic to arkosic sand. Excavations reveal foreset bedding with west to northwest dips as great as 25°. Clast population dominated by Columbia River Basalt Group and Pliocene or younger basalts from the Cascade Range; commonly includes Tertiary volcanic rocks, pre-Tertiary granitic and metamorphic rocks, and quartzite. Well logs indicate that gravel grades into mixed sand and gravel north of Fifth Plain Creek

BASIN-FILL DEPOSITS

Volcanic rocks

Qbgm **Basaltic andesite of Green Mountain (Pleistocene)**—Olivine phyric basaltic andesite erupted from cinder cone at west end of Green Mountain. Light-gray, microvesicular, generally platy lava flow, extending about 1 km to northwest of Green Mountain, consists of olivine phenocrysts (2-4 percent; 0.5 to 3 mm across; contains inclusions of chromian spinel; rims variably replaced by iddingsite) in a fine-grained trachytic groundmass of plagioclase, clinopyroxene, orthopyroxene, and Fe-Ti oxide; locally contains quartzite pebbles and small, dark, fine-grained clots that may be sedimentary xenoliths, both presumably derived from underlying gravels (units QTc and Ttfc). Conical hill at west end of Green Mountain consists largely of deeply weathered basaltic ash; platy basaltic andesite lava crops out at summit and presumably fills vent. Lava flow has normal magnetic polarity (J.T. Hagstrum, written commun., 1999) and yielded an $^{40}Ar/^{39}Ar$ age of 575±7 ka (table 2)

Qbmc **Basalt of Matney Creek (Pleistocene)**—Olivine-phyric and augite-microphyric basalt erupted from breached cinder cone south of Matney Creek. Light to dark gray, microvesicular to scoriaceous lava flow consists of olivine phenocrysts (about 5 percent; 0.5 to 2 mm across; with inclusions of chromian spinel; variably replaced by iddingsite), greenish augite microphenocrysts (2-3 percent; 0.2 to 0.5 mm long; commonly in multigrain clots), and rare plagioclase phenocrysts in a dark, trachytic, cryptocrystalline groundmass with traces of vapor-phase phlogopite. Cinder cone about 1.5 km to the northeast of Brunner Hill consists of weathered, dark grayish- to reddish-brown scoria. Overlies unnamed conglomerate (QTc). Chemically and petrographically similar to basaltic andesite of Brunner Hill, and presumed to be of similar age

Qbbh **Basaltic andesite of Brunner Hill (Pleistocene)**—Olivine-phyric and augite-microphyric basaltic andesite erupted from cinder cone at Brunner Hill. Light- to dark-gray, microvesicular to scoriaceous flow consists of olivine phenocrysts (4-5 percent; 0.5 to 2 mm across; with inclusions of chromian spinel; variably replaced by iddingsite), greenish augite microphenocrysts (1-3 percent; 0.2 to 0.5 mm long; commonly in multigrain clots), and rare plagioclase microphenocrysts in a trachytic to intergranular groundmass of plagioclase, clinopyroxene, olivine, Fe-Ti oxide, and minor interstitial glass; locally contains xenocrysts of plagioclase and quartz and round quartzite pebbles derived from underlying conglomerates in units QTc and Ttfc. Cinder cone is made up of weathered, dark grayish- to reddish-brown scoria Sample of lava flow collected to southwest of Brunner Hill has $^{40}Ar/^{39}Ar$ age of 627±9 ka (table 2)

Sedimentary rocks

QTc **Conglomerate (Pleistocene and (or) Pliocene)**—Unconsolidated to semiconsolidated, thick-bedded, pebble to boulder conglomerate with matrix of volcanic lithic to micaceous, quartzofeldspathic sand. Highly weathered and poorly exposed in map area; thickness uncertain but probably no more than 50 m. Clast population dominated by volcanic rocks eroded from western Cascade Range and Columbia River Basalt Group, includes minor quartzite. Poorly sorted to moderately well sorted and clast-supported, with clasts as large as 20 cm; most clasts well rounded but some porphyritic clasts subangular. Equivalent to alluvial-fan member of Troutdale Formation of Howard (2002). Age uncertain; unit overlain and (or) intruded by approximately 650,000-year-old basaltic andesite (Qbgm); probably late Pliocene to early Pleistocene

Troutdale Formation (Pliocene and Miocene?)—Semi-consolidated to well consolidated conglomerate and sandstone. Divided into two informal members separated by an unconformity

Ttfh **Hyaoclastic sandstone member (Pleistocene or Pliocene)**—Indurated, coarse-grained sandstone and granule conglomerate composed largely of glassy to lithic basaltic debris; commonly contains dispersed pebbles and cobbles; cobble conglomeratic beds locally abundant. Crops out on northern shores of Lacamas Lake and in bed of Lacamas Creek west of Lacamas Campground. Equivalent to rocks called vitric sandstone by Trimble (1963) and Tolan and Beeson (1984) and correlative with strata in the type area of the Troutdale Formation along the Sandy River in Oregon (Hodge, 1938). Thickness in map area unknown but increases to southwest and may exceed 50 m. Typical sandy beds are massive, moderately well sorted, crudely stratified, and commonly crossbedded; consist of angular to subrounded fragments 2 to 6 mm across of black, generally nonvesicular basalt containing crystals of olivine (as much as 2 mm across) and plagioclase (as much as 3 mm long) in a vitric to tachylitic to intergranular groundmass. Vitric clasts contain abundant pale brown sideromelane that is variably altered to palagonite, which imparts a distinctive yellowish-brown color to the originally dark green rock; clasts cemented by smectitic clay produced during palagonitization. Many beds contain minor amounts of admixed nonvolcanic debris such as quartz, muscovite, hornblende, and quartzite grains. Well rounded to subrounded pebbles and cobbles include varying proportions of olivine-phyric basalt, basaltic rocks of the Columbia River Basalt Group, quartzite, and other rock types. Angular nonvesicular vitric clasts probably formed by rapid chilling and quench fragmentation during interaction of basaltic lava with water; cross-stratification, interbedding with conglomerate, and mixing with nonvolcanic debris indicate deposition in fluvial environment, but textural immaturity and monolithologic character of many beds suggest transport was limited. Interpreted as hyaloclastic debris that was generated by basaltic eruptions in the Columbia River Gorge, and rapidly transported downstream and redeposited in eastern Portland Basin (Trimble, 1963; Tolan and Beeson, 1984; Swanson, 1986). Equivalent to informal upper member of Troutdale Formation mapped by Tolan and Beeson (1984) in Columbia River Gorge. Overlain by unnamed conglomerate (QTc)

Ttfc **Conglomerate member (Pliocene and (or) Miocene)**—Massive to crudely stratified, pebbly and cobbly conglomerate with sparse to abundant lenses of friable to lithified, arkosic to basaltic sandstone; poorly sorted to well sorted and clast-supported, with openwork fabric or sandstone matrix. Underlies broad, dissected surface that slopes south to southwest from about 550 ft to 450 ft (170 m to 135 m) elevation north of Shanghai Creek; also underlies Camp Hill, Munsell Hill, east part of Green Mountain ridge, and area east of Brunner Hill. Generally less than 75 m thick. Cobbles of basalt from the Columbia River Basalt Group dominate, but light-colored granitic and quartzofeldspathic metamorphic rocks and distinctive, white to light-gray, iron-oxide stained quartzite clasts are generally abundant; clasts of volcanic rocks eroded from Cascade Range are uncommon. Sandstone interbeds and matrix of conglomerate range from basaltic grit to micaceous arkose. These rock types indicate dominant source areas east of the Cascade Range and deposition by the ancestral Columbia River. Sedimentary structures suggest deposition in a gravel-bed braided river system; clast imbrication in exposure near Hockinson indicates northward transport direction. In most places, upper several meters weathered to reddish-brown clayey soil; in such areas, presence of scattered quartzite pebbles in soil is only indicator of conglomeratic parent material. Equivalent in part to upper member of Troutdale Formation of Mundorff (1964); correlative with lower member of Troutdale Formation of Tolan and Beeson (1984) and with quartzite-clast member of Troutdale Formation of Howard (2002) (see fig. 4). Age inferred from stratigraphic relations outside of quadrangle (Tolan and Beeson, 1984)

Tsr **Sandy River Mudstone (Miocene)**—Semiconsolidated, well-bedded sandstone, siltstone, claystone, and minor quartzite-bearing pebble conglomerate, pumice-lapilli tuff, and lignite. Rarely exposed in map area; distribution inferred chiefly from water-well logs, which indicate unit is as much as 300 m thick near Green Mountain. Where exposed outside of map area, consists largely of fluvial sediment, the composition of which indicates an eastern Washington or Idaho provenance and deposition by the ancestral Columbia River. Unconformably rests on Paleogene bedrock; disconformably overlain by Troutdale Formation (Ttfc and Ttfh). Equivalent to lower member of Troutdale Formation of Mundorff (1964) and fine-grained member of Troutdale Formation of Howard (2002). Age poorly constrained. Plant fossils from near top of unit at localities outside of quadrangle assigned late Miocene or Pliocene ages (Trimble, 1963; Mundorff, 1964; Tolan and Beeson, 1984)

BEDROCK

Volcanic and sedimentary rocks

Tbem **Basaltic andesite of Elkhorn Mountain (Oligocene)**—Sequence of tholeiitic basaltic andesite and basalt flows and flow breccia. Constitutes all Tertiary bedrock in map area and underlies large areas to north, east, and south (Evarts, 2006; R.C. Evarts, unpub. data). Flows are dark-gray to brown, porphyritic to seriate to aphyric, locally columnar-jointed, commonly weather into spheroidal blocks 1 to 3 m across. About 250 m thick in northeast part of map area; unit locally contains sedimentary interbeds too thin or too poorly exposed to map. Individual flows typically about 5 to 8 m thick, range up to 50 m thick. Typical porphyritic flows contain phenocrysts and glomerocrysts of weakly zoned plagioclase (as much as 55 percent; 1 to 6 mm, rarely more than 10 mm long; variably replaced by zeolites and (or) clay) and olivine (less than 2 percent; 0.5 to 3 mm across; commonly partly resorbed and surrounded by rinds of granular pyroxene and (or) magnetite; rarely contain minute chromian spinel inclusions; almost invariably replaced by some combination of smectite, hematite, carbonate, serpentine, quartz and kaolinite). Some flows also contain phenocrysts of augite (less than 1 percent; 0.5 to 1 mm across) and microphenocrysts of Fe-Ti oxide. Groundmass consists of plagioclase, augite, Fe-Ti oxide, and minor to abundant interstitial glass (largely devitrified or replaced by smectite, quartz, or calcite); groundmass textures chiefly intergranular to trachytic, less commonly subophitic or microphyric. All flows in unit are tholeiitic, and many are exceptionally rich in Fe (FeO* as high as 12.8 wt. percent) and poor in Sr (mostly less than 320 ppm) compared to mafic rocks elsewhere in southern Washington Cascade range (Evarts, 2001, 2002, 2004a, b, 2005, 2006; R.C. Evarts, unpub. data). Knob about 2 km northwest of Little Elkhorn is underlain by brick-red, zeolitized agglomerate composed of scoriaceous, plagioclase-phyric, basaltic andesite lapilli; may be remains of parasitic cinder cone

Contact—Dashed where approximately located; short-dashed where inferred; dotted where concealed

Fault—Dashed where inferred; dotted where concealed. Ball and bar on downthrown side. Arrows show relative horizontal movement

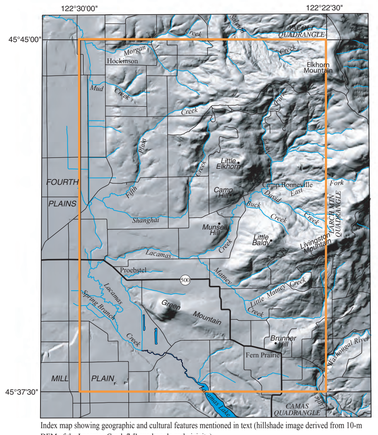
Relative motion of faults on cross section—x denotes motion away from viewer; dot denotes motion towards viewer

Strike and dip of platy parting in lava flows

Sample locality for chemical analysis—See table 1

Sample locality for $^{40}Ar/^{39}Ar$ age determination and age (±1-σ error)—See table 2

Cinder cone



Index map showing geographic and cultural features mentioned in text (hillshade image derived from 10-m DEM of the Lacamas Creek 7.5' quadrangle and vicinity)

Geologic Map of the Lacamas Creek Quadrangle, Clark County, Washington

By

Russell C. Evarts

2006

For sale by U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225, 1-888-ASK-USGS

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