State of Oregon
Department of Geology and Mineral Industries
Dr. Vicki S. McConnell, State Geologist

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PRELIMINARY GEOLOGIC MAP OF THE HUSTON LAKE 7.5′ QUADRANGLE, CROOK COUNTY, OREGON

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2006

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INTRODUCTION

The Huston Lake 7 ½’ quadrangle resides on the eastern margin of the Deschutes Basin near the intersection of the High Cascades, High Lava Plains, and Blue Mountains geomorphic provinces. Located downstream of the city of Prineville at the junction of the Crooked River and McKay Creek, the quadrangle encompasses a historic ranching community that is transforming to a rural residential population. Topographic relief in the juniper- and sage-covered high desert terrain ranges from 3605 ft (1099 m) at Meyers Butte to 2802 ft (854 m) in the Prineville Valley, downstream of the city of Prineville. This map depicts a preliminary stratigraphic assessment for the Prineville area and provides a framework for further geologic and geohydrologic analysis of the Lower Crooked River Basin.

The Huston Lake quadrangle consists of a succession of Tertiary volcanic and sedimentary strata and includes from oldest to youngest: 1) Oligocene (?) to Miocene sedimentary rocks; 2) lava flows of the middle Miocene Prineville Basalt; 3) late Miocene to Pliocene sediments and lava flows of the Deschutes Formation; 4) Pliocene basalt lava flows of Dry River; and 5) Quaternary surficial and valley fill deposits. Oligocene-Miocene sedimentary rocks and the Prineville Basalt form an irregular, variably eroded and structurally deformed, middle Miocene surface that is exposed along the Crooked River in the northwestern portion of the quadrangle. The overlying succession of plateau forming Deschutes Formation lava flows, basalt vents, and sedimentary rocks that cover much of the surface of the mapped area fill channels incised into the Prineville Basalt. The basalt of Dry River is inset into and onlaps lava flows of the Deschutes Formation in the southwest corner of the quadrangle. Quaternary alluvium and terrace deposits of the Crooked River and tributary streams fill modern drainages; landslide deposits derived from late Miocene basalt flows line canyon walls.

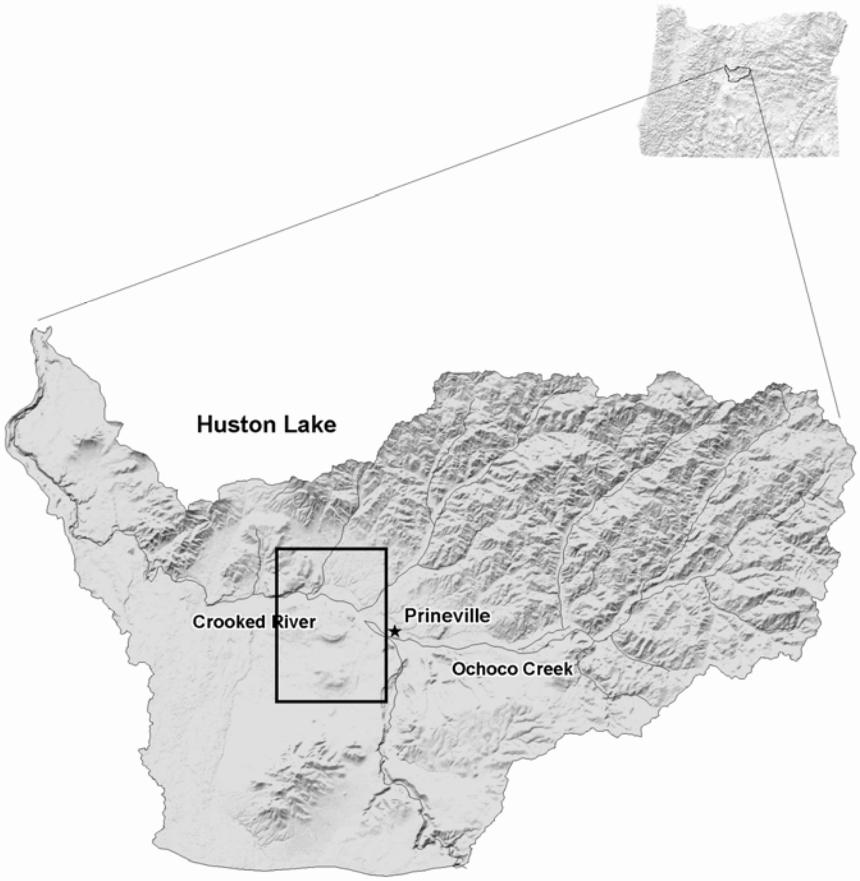

Figure 1. Digital Elevation Model (DEM) of the Lower Crooked River Basin, showing location of the Huston Lake quadrangle.

Methodology and Previous Work

The 1:24,000 scale geologic map of the Huston Lake quadrangle was funded by the USGS National Cooperative Geologic Mapping Program. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government. The map is released as an interim open-file map product as part of a larger mapping project covering the Lower Crooked River Basin (Figure 1) and has not yet been peer reviewed. The United States Government is authorized to reproduce and distribute reprints for governmental use. Geologic data were collected at the 1:24,000 scale combining new mapping with published and unpublished data from air photos, orthophotoquads, and digital shaded relief images derived from USGS 10 m DEM (Digital Elevation Model) grids. Mapping was supplemented with x-ray fluorescence (XRF) geochemical analyses from Franklin and Marshall College. Age-date samples were prepared and analyzed by the College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon. Subsurface geology in cross sections is based on analyses of water-well drill records.

Detailed geologic maps of the Prineville area are of comparatively recent vintage. The first large scale reconnaissance geologic maps for the area were made by Hodge (1942) and Williams (1957). Later mapping efforts focused on groundwater studies and mercury mineralization (Robinson and Price, 1963; Waters and Vaughn, 1968), enabling Swanson (1969) to produce a more detailed 1:250,000 scale map of the east half the Bend AMS sheet. Subsequent studies included an investigation of the geothermal potential at Powell Buttes (Brown and others, 1980). In the 1990’s, the U.S. Geological Survey and Oregon Department of Water Resources began a detailed study of the upper Deschutes Basin; (Gannett and others, 2001; Lite and Gannett, 2002). The current mapping effort is designed in part to better define the geologic conditions along the eastern margin of the upper Deschutes Basin, building off of the stratigraphy established by Smith (1986a) and Sherrod and others (2004).

PRELIMINARY DESCRIPTION OF GEOLOGIC UNITS – HUSTON LAKE 7 ½’ QUADRANGLE, CROOK COUNTY, OREGON

Surficial Deposits

Qa **Alluvium (Holocene and late Pleistocene)** – Gravel, sand, and silt deposited in active stream channels and on adjoining flood plains. Includes gravel and channel sand deposited in active or recently active channels and overbank fines deposited on the modern flood plain of the Crooked River.

Qls **Landslide deposits (Holocene and Pleistocene)** – Unconsolidated, clast-supported, interlocking breccia deposited from gravity-driven mass-wasting processes including toppling, en masse rotation, and rock avalanches. Clasts range from 1-3-m-across, with the maximum intact landslide blocks up to 300-m-across. Crackle- and jigsaw-breccia fabrics are common in clasts (sensu stricto Yarnold and Lombard, 1989). Landslides originate from oversteepened, tension-cracked cliff-faces that calve and topple or rotate listrically along fractured columnar joint margins. Older slides have vegetated and soil-mantled upper surfaces; more recent deposits lack vegetation and soil and in places may be confused for tumuli capped intracanyon lava flows. Thickness is highly varied; maximum thickness several tens of meters.

Qt **Terrace deposits (Pleistocene)** – Abandoned terraces of the Crooked River. Based on water well logs, the terrace deposits consist of brown clay, well-sorted gravel, and brown sand. Maximum thickness of the unit is approximately 20 m. Equivalent in part to fluviolacustrine sediments (Qpa) of Robinson and Price (1963) and unit Qs of Swanson (1969).

Tertiary Volcanic and Sedimentary Rocks

Tpb **Basalt of Dry River (Pliocene)** – Gray, fine-grained, open-textured olivine-phyric basalt flows that onlap Grass Buttes in the southwest portion of the quadrangle. The top of the Dry River flow is marked by hummocky tumuli; this surface retards groundwater infiltration creating a semi-saturated ground layer with abundant ponds. In thin-section, the basalt is aphyric with a groundmass of plagioclase lathes set in a matrix of intergranular olivine, clinopyroxene, and subophitic clinopyroxene crystals. Chemically it is a high alumina basalt with characteristically low amounts of potassium. A representative sample has 50.37 weight percent SiO_2; 16.68 weight percent Al_2O_3; 1.46 weight percent TiO_2; and 0.41 weight percent K_2O (Sample 14, Table 1.1). The basalt displays reversed magnetic polarity and is not mantled by eroded sands of unit Tdsg. Sherrod and others (2004) consider the basalt of Dry River to be about the same age as the basalt of Redmond, which has an $^{40}Ar/^{39}Ar$ whole rock age of 3.56 $\pm$ 0.30 Ma (Smith, 1986a).

Td – Deschutes Formation (Pliocene and late Miocene) – Interbedded lava flows and sedimentary rocks. Equivalent to the Deschutes Formation of Smith (1986a) and subdivided into:

Tdsg **Plateau mantling sand and gravel (Pliocene and late Miocene?) –** Degraded, unconsolidated sand and gravel capping middle to late Miocene plateau-forming basalts. The sand component is fine-to medium-grained, well-sorted, and consists of angular to subround grains of clear feldspar (70 percent by volume), amphibole (15 percent), white pumice (10 percent), quartz (3 percent), and magnetite (2 percent). Some mineral grains maintain a euhedral crystal form. The gravel consists of surface-armoring lag-deposits and in-situ reworked upper surfaces of basalt lava flows. The highstand for Deschutes sediments is estimated to be approximately 3600 ft (1096 m) in elevation based on distinctive sand and gravel strand lines observed on Powell Buttes and correlative sediment that caps both Meyers Butte (elev. 3605 ft, 1099 m) and Grass Butte (elev. 3602 ft, 1098 m). Unit Tdsg is unconformably overlain by the basalt of Dry River (Tpb). Maximum thickness is unknown.

Tdp **Vent pyroclastic rocks (Pliocene and late Miocene?) –** Unconsolidated cindercones associated with basalt vents at Grass Butte, Meyers Butte, and west of Round Butte. All pyroclastic cones are mantled by sand and gravel of unit Tdsg. The cindercone at Grass Butte consists of well-stratified, stacked 1-m-thick beds, of red and black, pebble-sized scoria and intervals of spatter. The deposits are moderately to well-sorted with interspersed cobble- to boulder-sized, fluidal volcanic bombs up to 1.5-m-across. A prominent, 1- to 2-m-thick bed of welded scoria, spatter, and breccia, occurs in the mid- to upper part of the excavated section of the crater. Crater wall angular unconformities indicate episodes of structural collapse and cone regrowth. The Grass Butte cindercone is capped by a 1- to 2-m-thick vesicular, olivine basalt flow. The Meyers Butte cindercone and satellites to the northwest consist of interbedded, red and black scoria, agglutinate, and spatter. A geochemical analyses of a basalt bomb from the cone west of Meyers Butte (Sample 10, Table 1.1) is very similar to analyses of the Meyers Butte flows (Tdbm2, Tdbm1), with 49.92 weight percent SiO_2; 16.15 weight percent Al_20_3; 1.67 weight percent TiO_2; and 0.72 weight percent K_20. The unit also includes white to tan, well-stratified, poorly-sorted, lithic-rich, matrix-supported breccia and red-oxidized, normally graded cross-bedded sandstone interbedded with scoriaceous volcanic ejecta. White, massive, tuffaceous siltstone fills a 0.75-m-thick by 10-m-wide depression in stratified scoria deposits along the northern edge of the excavated crater at Meyers Butte. The Meyers Butte cindercone is capped by 2 m of massive, matrix-supported, pumice- and scoria-rich cobble conglomerate. West of Round Butte, the deeply eroded cone consists of intensely welded agglutinate and scoria.

Tdbr **Basalt of Round Butte (late Miocene)** – Gray, fine- to medium-grained, olivine-phyric basalt flow forming the canyon rim on the north side of the Prineville Valley in the NW corner of the quadrangle. Cliff-forming, columnar jointed, tumuli-capped basalt flows of Round Butte rest directly on flows of the Prineville basalt. The vent for the flow is located 2 miles west of Round Butte in the SE ¼ of section 13 of T14S, R14E. In thin section the basalt has iddingtized olivine phenocrysts set in a micro-plagioclase matrix with intergranular olivine. The Round Butte flows are basalt in composition, with approximately 50.87 weight percent SiO_2; 15.84 weight percent Al_2O_3; 1.65 weight percent TiO_2; and 0.72 weight percent K_2O (Sample 2, Table 1.1)

Tdib **Basalt feeder dikes (late Miocene) –** Erosionally resistant, vertically-oriented olivine-plagioclase-phyric and olivine-phyric basalt and basaltic andesite dikes that invade and crosscut pyroclastic rocks (unit Tdp) near Round Butte and at Grass Butte. The feeder dike to the basalt of Round Butte on the north side of the Prineville Valley is up to 18-m-across, trends N25^{o}W, crosscuts cliff-forming exposure of the Prineville Basalt, and is capped by a low lying cone of basalt, welded spatter, and scoria. Dikes crosscutting vent pyroclastic material at Grass Butte range from 0.5-m to 3-m-across and trend from N20^{o}W to N60^{o}W. These dikes display irregular intrusive margins, vesicles stretched parallel to the dike margins, and numerous blocky silicic xenoliths and well-rounded, ovate spheroid xenoliths of olivine-phyric basalt. The dike near Round Butte is nearly identical in composition to the Round Butte flow, with 51.00 weight percent SiO_2; 15.88 weight percent Al_2O_3; 1.38 weight percent TiO_2; and 0.75 weight percent K_2O (Sample 3, Table 1.1). Dikes at Grass Butte are nearly identical to composition of the Grass Butte flows, with approximately 52.75 weight percent SiO_2; 15.20 weight percent Al_2O_3; 1.75 weight percent TiO_2; and 0.95 weight percent K_2O (Samples 15 and 17, Table 1.1).

Tdbm **Basalt of Meyers Butte (late Miocene)** – Olivine basalt flows in the Deschutes Formation. Subdivided, on basis of stratigraphic position and, locally, the presence of sedimentary interbeds into:

Tdbm2 upper flow package (late Miocene) – Dark-gray, medium-grained, vesicular olivine-phyric basalt flow that marks the top of the Deschutes Formation along the canyon wall of the Crooked River. Exposures in the canyon show massive columnar, tumuli capped, overlapping flow-lobes. Individual flow lobes have well-defined outer vesicular margins that grade inward to a massive crystalline core. Locally, the flow retains hollow lava tubes ($\leq$ 2 m-wide) and vesicle cylinders ($\leq$ 3 cm-wide). In thin section the basalt is holocrystalline with a diktytaxitic texture marked by plagioclase crystals that protrude into the vesicles. Microporphyritic with glomerocrysts of olivine and plagioclase crystals. Groundmass plagioclase crystals are set in a subophitic clinopyroxene matrix. Samples from the quadrangle indicate that the flows are high alumina basalt with moderate titanium and potassium, with ~49.50 weight percent SiO_2; 16.80 weight percent Al_2O_3; 1.45 weight percent TiO_2, and 0.42 weight percent K_2O (Samples 11, 12, and 25, Table 1.1). Reversed magnetic polarity. The upper flow has a radiometric age of 5.42 ± 0.11 Ma (Sample A1, plate 1; Table 1.2).

Tdbm1 lower flow package (late Miocene) – Gray, medium- to coarse-grained, vesicular plagioclase- olivine-phyric basalt resting directly beneath Tdbm2 in the west wall of the Crooked River Canyon. Includes, at the base, a palagonite breccia more than 20-m-thick that is made up of sub-angular, black, glassy basalt blocks, bombs, and pillows. In thin section, the basalt is holocrystalline and diktytaxitic. The unit contains microphenocrysts of plagioclase and olivine set in a groundmass of plagioclase lathes and subophitic clinopyroxene crystals. Based on analyses from the quadrangle, the unit is chemically indistinguishable from overlying unit Tdbm2, with moderate titanium and potassium contents, with 49.23 weight percent SiO_2; 16.62 weight percent Al_2O_3; 1.38 weight percent TiO_2, and 0.35 weight percent K_2O (Sample 26, Table 1.1). Locally interbedded with tuffaceous sandstone. The basalt displays reversed magnetic polarity.

Tdv **Basalt vents (late Miocene) –** Low-profile shields composed of open-textured plagioclase-phyric and olivine-phyric basaltic andesite and basalt lava flows that form Grass Butte and Meyers Butte. In thin section Grass Butte vent flows are holocrystalline and olivine-phyric with iddingtized olivine phenocrysts. Chemically Grass Butte vent rocks are low alumina basaltic andesite with moderate amounts of titanium and high amounts of strontium, with ~52.70 weight percent SiO_2; 15.00 weight percent Al_2O_3; 1.80 weight percent TiO_2, 0.95 weight percent K_2O; and ~ 1,000 ppm Sr (Samples 16 and 18, Table 1). In thin section Meyers Butte vent flows are plagioclase- and olivine-phyric with subophitic clinopyroxene and groundmass olivine. Chemically, Meyers Butte vent rocks are high alumina basalt with moderate titanium and potassium, with ~49.15 weight percent SiO_2; 16.77 weight percent Al_2O_3; 1.46 weight percent TiO_2, and 0.41 weight percent K_2O (Sample 13, Table 1.1). Basalt vents are capped or flanked by cindercones of unit Tdp and are mantled by degraded sediment of unit Tdsg.

Tdbg **Basalt of Grass Butte (late Miocene) –** Gray, medium-grained, open-textured, vesicular olivine- and plagioclase-phyric basaltic andesite flows flanking Grass Butte. In thin section the basaltic andesite is holocrystalline and olivine-phyric with iddingtized olivine phenocrysts. Chemically the Grass Butte flow is a low alumina basaltic andesite with moderate amounts of titanium and high levels of strontium; with 53.07 weight percent SiO_2; 15.60 weight percent Al_2O_3; 1.74 weight percent TiO_2, 0.92 weight percent K_2O, and 1,040 ppm Sr) (Sample 20, Table 1.1). The Grass Buttes flows are onlapped by the basalt of Meyers Butte (Tdbm2) on the east and the basalt of Dry River on the west. The basalt is covered by sediment of unit Tdsg on the north and south.

Tdbw **Basalt of White Deer Ranch (late Miocene)** – Gray, medium-grained, vesicular, olivine-phyric basalt flows. In thin section, the basalt is holocrystalline, with a diktytaxitic texture. Microphenocrysts of plagioclase and olivine are set in a groundmass of plagioclase surrounded by subophitic clinopyroxene crystals. Chemically the units is a basalt with relatively high amounts of titanium and low amounts of strontium, with 48.25 weight percent SiO_2; 15.85 weight percent Al_2O_3; 2.00 weight percent TiO_2, 0.56 weight percent K_2O, and 313 ppm Sr. A late Miocene age is based on stratigraphic position. The basalt displays reversed magnetic polarity and rests directly beneath the Rattlesnake Ash-flow Tuff (Tmr) in the Crooked River Canyon in the Powell Buttes quadrangle.

Tds **Sedimentary rocks (late Miocene)** – Black to brown, plane-parallel stratified to cross-stratified volcaniclastic sandstone, siltstone, and conglomerate. Sedimentary rocks are laterally discontinuous, interfinger with lava flows, are weakly consolidated and poorly exposed weathering to form soil-mantled hillslopes. These rocks form the base of the middle to late Miocene plateau capping basalts and are considered to be correlative to the Deschutes Formation as defined by Farooqui and others (1981). The composite sedimentary section may be as much as 120-m-thick in the quadrangle. The base of the sedimentary section is not exposed.

Tcp **Prineville Basalt (middle Miocene)** – Black to dark gray, fine-grained, sparsely plagioclase-phyric and aphyric, iron-rich basaltic andesite, trachyandesite, and basaltic trachyandesite lava flows. The Prineville Basalt forms cliff exposures along the Crooked River in the northwest part of the quadrangle and is exposed in a quarry cut south of Grass Butte. Outcrops are massive to columnar-jointed with lesser amounts of spheroidal weathering; locally the base of flows are composed of palagonite breccia and detached pillows encased in tuffaceous sedimentary rocks of unit Tmos. In thin section the basalt is hypocrystalline, with 60 percent crystals, and 40 percent glass, with a hyalopilitic groundmass texture made up of glass, plagioclase lathes, clinopyroxene grains and abundant opaque mineral grains. The basalt contains < 2 percent olivine microphenocrysts. The basalt flows are equivalent to the Prineville Basalt as defined by Tolan and others (1989) and Hooper and others (1993). Prineville flows in the quadrangle include Bowman Dam, Hi-Si (Samples 1, 7, and 9, Table 1.1), and Hi-PT (Samples 5 and 8, Table 1.1) chemical types as defined by Hooper and others (1993) and are chemically characterized by a range of silica values (SiO_2 from 50.81 to 55.68 weight percent) and elevated concentrations of phosphorus (P_2O_5 from 1.50 to 1.78 weight percent) and barium (Ba from 1911 to 2728 ppm) (Samples 1, 4, 5, 6, 7, 8, 9, 21, 23,and 24; Table 1.1). Flows at the top of the section south of Green Butte are all Bowman Dam type flows (Samples 21 and 24, Table 1.1). According to Hooper and others (1993), lower Bowman Dam type flows display reversed magnetic polarity while the upper Bowman Dam type flows, Hi-Si, and Hi-PT flows display normal magnetic polarity. A middle Miocene age is based on a radiometric date of 15.7 ± 0.1 Ma (Smith, 1986a) on the basal flow at Pelton Dam in the Deschutes Basin and intertonguing relationships between reversed magnetic polarity Bowman Dam type flows and R2 Grande Ronde Basalt flows north of the Deschutes Basin (Hooper and others, 1993).

Tmos **Volcaniclastic sedimentary rocks (middle Miocene to late Oligocene?)** – Moderately indurated deposits of brown to tan tuffaceous siltstone, white to dark gray, plane-parallel stratified to massive volcaniclastic sandstone, massive, white pumice-lithic tuff, and massive, gray pumice-obsidian-lithic tuff. A middle Miocene age for the upper part of the unit is based upon invasive, intertonguing relationships and/or conformable upper contacts with the Prineville Basalt. Typically, Tmos sedimentary rocks are intruded and displaced by pillow structures at the base of Prineville basalt flows. Although previously considered to be the upper part of the John Day Formation (Swanson, 1969) herein tentatively considered to be correlative to the Simtustus (Smith, 1986b) and Mascall (Merriam, 1901) Formations. Contact relationships with the upper part of the John Day Formation are not known. The base of the unit is not exposed in the quadrangle.

STRUCTURE

Major structures in the Huston Lake quadrangle include northwest and north-northwest trending normal faults and a northwest trending flexure in the Prineville Basalt. Faults are generally poorly exposed and their locations are inferred on the basis of apparent stratigraphic offset of marker beds, slickenside coated surfaces, and stratigraphic interpretations of water-well drill logs. Along the O'Neil Highway and at Round Butte conformable sedimentary strata of unit Tmos and Prineville basalt are rotated along north, northeast trending normal faults to a strike orientation of N65^{o}E and a dip of ~15^{o}N. To the north, middle Miocene strata are relatively flat lying, displaced by a stair-step succession of top to the north, northeast trending normal faults. South of the Crooked River, water-well drill logs indicate that the upper surface of the middle Miocene sedimentary and basalt section flattens, hinging on an east-west trending, gentle monoclinal fold. A perpendicular, north-northwest trending normal fault segments the entire exposed middle Miocene section near Round Butte with an inferred top to the east sense of displacement. Structures (see plate 1) denoted in the subsurface beneath Qal deposits and the Deschutes Formation Plateau are inferred from bedding attitudes and detailed analyses of well-water drill logs. Faults only deform middle Miocene and older strata; structural displacement does not affect younger rocks of the relatively stable Deschutes Formation volcanic plateau. Late Miocene basalt vents of the Deschutes Formation show an alignment that is crudely similar to that of the inferred north-northwest trending normal fault structure.

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Table 1.1. Analyses of major oxide and selected trace elements from samples collected in the Huston Lake quadrangle, Crook County, Oregon. Major oxides in percent and selected trace elements in parts per million (ppm). XRF analyses normalized to 100 percent on a volatile-free basis with total iron expressed as FeO_. Samples analyzed by the Franklin and Marshall College, GeoAnalytical Laboratory, Lancaster, PA. Sample location numbers are keyed to the accompanying preliminary geologic map.

Map #	1	2	3	4[a]	5[a]	6[b]	7[b]
UTM_N	4915123	4914050	4912323	4912100	4911170	4911190	4911230
UTM_E	0662791	0660600	0660282	0661100	0660340	0660430	0660570
Group	CRBG			CRBG	CRBG	CRBG	CRBG
Formation	Prineville	Deschutes	Deschutes	Prineville	Prineville	Prineville	Prineville
Map unit	Tcp	Tdbr	Tdbr	Tcp	Tcp	Tcp	Tcp
Lithology	Basaltic Andesite	Basalt	Basalt	Basaltic trachyand.	Trachy-basalt	Basalt	Basaltic trachyand.
SiO2	53.66	51	50.87	51.66	50.84	50.83	54.11
Al2O3	14.74	15.88	15.84	13.86	13.75	14.32	15.22
TiO2	2.84	1.38	1.65	2.65	3.13	3.15	2.74
FeO_	10.07	9.47	9.98	12.44	12.12	12.47	9.83
MnO	0.21	0.16	0.18	0.24	0.23	0.26	0.22
CaO	8.4	9.93	9.78	7.92	8.79	8.46	6.89
MgO	3.41	8.35	7.66	4.28	3.85	4.86	3.79
K2O	1.96	0.75	0.79	2.13	1.67	1.47	2.85
Na2O	3.21	2.64	2.79	3.37	3.61	2.58	3.04
P2O5	1.52	0.44	0.46	1.46	2.02	1.57	1.32
Ni	7	179	133	9	17	n.d.	n.d.
Cr	22	355	255	14	13	n.d.	n.d.
Sc	37	31	28	36	45	n.d.	n.d.
V	337	220	226	318	318	n.d.	n.d.
Ba	1973	460	524	1987	3202	n.d.	n.d.
Rb	45	9	11	43	29	n.d.	n.d.
Sr	428	644	548	384	413	n.d.	n.d.
Zr	182	131	153	150	131	n.d.	n.d.
Y	58.3	27.6	33.8	50	53	n.d.	n.d.
Nb	8.7	9.8	12.2	9	8.6	n.d.	n.d.

Ga	21	18	19	18	19	n.d.	n.d.
Cu	37	70	54	28	38	n.d.	n.d.
Zn	144	84	85	127	129	n.d.	n.d.
Pb	6	2	2	6	5	n.d.	n.d.
La	29	18	23	20	31	n.d.	n.d.
Ce	65	41	48	39	25	n.d.	n.d.
Th	4.6	1.9	2.1	4	4	n.d.	n.d.
U	3.1	1	0.7	n.d.	n.d.	n.d.	n.d.
Co	29	43	43	n.d.	n.d.	n.d.	n.d.

Map #	**8**	**9**	**10**	**11**	**12**	**13**	**14**
UTM_N	4912018	4912478	4909674	4909669	4910160	4908463	4904760
UTM_E	0663325	0663754	0661790	0665091	0666234	0665813	0659810
Group	CRBG	CRBG					
Formation	Prineville	Prineville	Deschutes	Deschutes	Deschutes	Deschutes	
Map unit	Tcp	Tcp	Tdp	Tdbm1	Tdbm1	Tdv	Tpb
Lithology	Trachy-basalt	Trachy-basalt	Basalt	Basalt	Basalt	Basalt	Basalt
SiO2	51.52	56.19	49.92	49.86	49.54	49.76	50.37
Al2O3	13.57	14.96	16.15	17.06	16.99	16.98	16.68
TiO2	3.05	2.7	1.67	1.46	1.45	1.48	1.46
FeO_	12.5	8.18	10.41	10.93	11.03	10.98	10.97
MnO	0.24	0.15	0.18	0.19	0.19	0.2	0.19
CaO	8.01	7.02	9.89	9.89	9.91	9.95	9.75
MgO	4.17	2.23	7.73	6.95	7.32	7.04	7
K2O	1.92	3.14	0.72	0.41	0.4	0.42	2.84
Na2O	3.22	3.87	2.82	2.93	2.88	2.9	0.41
P2O5	1.81	1.54	0.49	0.32	0.29	0.3	0.32
Ni	18	12	167	113	116	119	107
Cr	20	12	305	117	117	115	138
Sc	33	30	29	29	29	29	31
V	278	216	234	261	239	256	259
Ba	2728	2387	310	250	255	380	290
Rb	39	39	10	6	6	7	6
Sr	396	333	535	341	340	350	347
Zr	141	160	146	92	92	92	105
Y	52.5	52.4	30.5	30.2	29.1	31.8	32
Nb	7.8	8.7	12.1	5.3	5.2	5.1	5.5
Ga	20	21	19	20	20	20	20
Cu	47	49	73	86	94	89	91
Zn	116	109	93	85	84	84	90
Pb	3	6	3	2	2	2	1
La	28	29	15	11	13	12	12
Ce	61	64	37	25	29	26	28
Th	3.3	5.2	1.2	0.8	2.3	0.7	1.2
U	1.2	3.3	1.4	<0.5	1	0.7	0.9
Co	35	22	45	47	46	46	47

Map #	**15**	**16**	**17**	**18**	**19[b]**	**20**	**21**
UTM_N	4907507	4906250	4904470	4904480	4904450	4902870	4901547
UTM_E	0664282	0664300	0664820	0664930	0664990	0663200	0664913
Group							CRBG
Formation	Deschutes	Deschutes	Deschutes	Deschutes	Deschutes	Deschutes	Prineville
Map unit	Tdbg	Tdv	Tdib	Tdib	Tdv	Tdbg	Tcp

Lithology	Basaltic Andesite	Basaltic Andesite	Basaltic Andesite	Basaltic Andesite	Basaltic Andesite	Basaltic Andesite	Basaltic Andesite
SiO2	52.47	52.75	53.05	52.63	52.29	53.07	52.74
Al2O3	15.11	14.79	15.27	15.15	15.76	15.6	13.91
TiO2	1.74	1.78	1.76	1.84	2.01	1.74	2.72
FeO_	10.86	10.08	9.88	9.42	9.43	9.62	11.68
MnO	0.16	0.16	0.16	0.15	0.15	0.16	0.25
CaO	9.02	9.69	9.12	9.3	9.13	9.48	8.06
MgO	6.51	6.98	6.58	7.28	7.26	6.39	4.06
K2O	0.95	0.85	0.96	1.16	1.08	0.92	2.11
Na2O	2.83	2.64	2.86	2.69	2.56	2.7	3.02
P2O5	0.35	0.28	0.36	0.38	0.35	0.33	1.46
Ni	129	84	129	139	n.d.	107	12
Cr	245	223	245	249	n.d.	242	21
Sc	25	24	25	22	n.d.	23	36
V	205	220	205	211	n.d.	223	330
Ba	403	419	403	450	n.d.	617	1911
Rb	11	9	11	12	n.d.	10	45
Sr	951	925	951	1134	n.d.	1040	401
Zr	158	143	158	169	n.d.	146	171
Y	26	27.2	26.1	28.8	n.d.	29.1	53.1
Nb	10.5	8.3	10.5	10.9	n.d.	9.1	8.1
Ga	20	20	20	19	n.d.	20	21
Cu	27	42	27	59	n.d.	47	46
Zn	92	96	92	94	n.d.	93	125
Pb	1	4	1	6	n.d.	7	4
La	21	18	21	23	n.d.	24	25
Ce	4	40	46	49	n.d.	51	59
Th	2.8	1.9	2.8	1.5	n.d.	1.1	5.7
U	1	0.7	1.1	2.1	n.d.	1.4	2.2
Co	39	42	39	40	n.d.	38	35

Map #	**22**[c]	**23**[c]	**24**[c]	**25**	**26**
UTM_N	4907900	4907900	4907900	4902369	4902289
UTM_E	0668400	0668400	0668400	0669419	0669448
Group		CRBG	CRBG		
Formation	Deschutes	Prineville	Prineville	Deschutes	Deschutes
Map unit	Tdbw	Tcp	Tcp	Tdbm2	Tdbm1
Lithology	Basalt	Trachybasalt	Basaltic trachyande	Basalt	Basalt
SiO2	48.25	51.76	52	49.13	49.23
Al2O3	15.85	14	14.02	16.62	16.65
TiO2	2	2.72	2.75	1.38	1.43
FeO_	12.13	12.3	12.05	11.8	11.95
MnO	0.21	0.23	0.23	0.19	0.19
CaO	9.27	8.08	8.15	9.94	9.69
MgO	8.1	4.25	4.03	7.52	7.29
K2O	0.55	1.82	1.87	0.35	0.43
Na2O	3.18	3.37	3.4	2.77	2.82
P2O5	0.47	1.47	1.49	0.29	0.31
Ni	136	3	9	113	108
Cr	243	21	22	145	116
Sc	39	37	31	30	31
V	331	349	354	250	254
Ba	418	2185	2326	239	302

Rb	7	41	41	6	6
Sr	313	395	395	348	347
Zr	100	149	150	94	104
Y	30	49	49	28	30
Nb	6.8	8.6	9.6	5	5.9
Ga	19	20	22	20	20
Cu	76	109	35	90	83
Zn	100	169	133	82	86
Pb	0	5	5	2	4
La	16	20	25	11	13
Ce	1	3	3	2	2
Th	1	7	4	0.5	0.9
U	n.d.	n.d.	n.d.	1	0
Co	n.d.	n.d.	n.d.	47	47

[a] Hooper and others (1993); [b] Smith (1986); [c] Lite and Gannett (2003)

Table 1.2. Whole-rock $^{40}Ar/^{39}Ar$ age determination for the upper Meyers Butte basalt flow (Tdbm2) in the Huston Lake quadrangle, Crook County, Oregon. Sample A1 prepared and analyzed by the College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon. The sample location number is keyed to the accompanying preliminary geologic map.

Map #	Map label	Lithology	Age (Ma)	Method	Material dated	Formation	Utm_N	Utm_E
A1	Tdbm2	Basalt	5.42 ± 0.11	$^{40}Ar/^{39}Ar$	Whole rock	Deschutes	4909669	0665091