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Geologic Map of the Fly Valley Quadrangle,
Union County, Oregon
By M.L. Ferns
Text

Geology of the Fly Valley Quadrangle, Union County, Oregon

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INTRODUCTION

The Fly Valley quadrangle is located in the north-central Blue Mountains of northeastern Oregon, in southwest Union County, approximately 20 mi southwest of La Grande, Oregon (Figure 1). It lies in a heavily timbered, mountainous region and encompasses part of the headwaters of the Grande Ronde River. Elevation ranges from slightly under 4,100 ft on the Grande Ronde River in the northeast corner of the quadrangle to over 6,080 ft near the headwaters of Sheep Creek along the quadrangle's south boundary. Most of the timbered land is administered by the USDA Forest Service (USFS) and is part of the Wallowa Whitman National Forest. Public access is restricted on private lands along Sheep Creek and the Grande Ronde River.

The map area lies in the south-central part of the La Grande 30×60-minute quadrangle, which has been targeted for detailed geologic mapping under the STATEMAP program of the U.S. Geological Survey. Project goals include a 1:100,000-scale geologic map of the La Grande quadrangle, compiled from recent and ongoing Federal and State mapping projects. The finished 1:100,000-scale map will define the region's geologic framework at a scale suitable for site-specific assessment of geologic (bedrock, surficial, and structural) influences on hydrologic and soil-vegetation systems. New structural, geochemical, and lithologic data generated during the program are expected to aid in evaluations of seismic risk and mineral and hydrologic resources. Maps of a larger scale such as the Fly Valley quadrangle (1:24,000) form the basis from which the final map will be produced and will be systematically released as interim products as the La Grande mapping program progresses.

Although a considerable amount of new work (Swanson and others, 1981; Reidel and others, 1989; Hooper and Swanson, 1990; Hooper and others, 1995) has been done on the Columbia River Basalt Group, the major geologic unit that covers most of the La Grande 30×60-minute quadrangle, comparatively little work has been directed at the older Tertiary volcanic rocks that underlie the Fly Valley quadrangle. Earlier works include a 1:250,000-scale reconnaissance geologic map of the Pendleton quadrangle by Walker (1973) and a water-resource investigation by Hampton and Brown

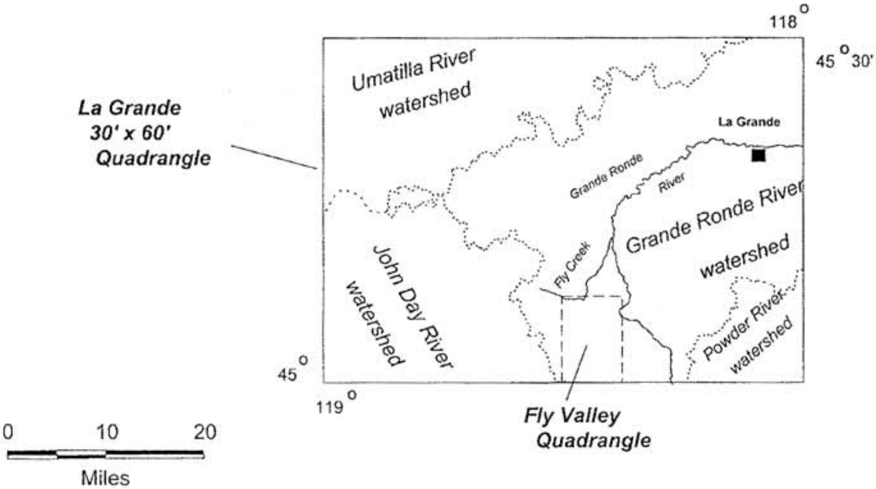

Figure 1. Sketch map of the La Grande 30' × 60' quadrangle. Rectangle marks location of Fly Valley 7½' quadrangle.

(1964). Recently mapped adjoining quadrangles include the 1:62,500-scale Desolation Butte quadrangle by Evans (1988) and the 1:24,000-scale Limber Jim Creek quadrangle by Ferns and Taubeneck (1994).

Whole-rock chemical data are useful in classifying volcanic rocks, since many are too fine grained and glassy to be adequately characterized by mineralogical criteria. The AFM diagram of Irvine and Baragar (1971), which is based on the relative abundance of iron, is used to separate "tholeiitic" from "calc-alkaline" rocks. Chemical criteria used by Taylor (1978) and Taylor and Ferns (1995) for calc-alkaline volcanic rocks are based on chemical analyses recalculated to a 100-percent total without volatiles and with all iron calculated as Fe^{+2}:

Silica $<$ 53 weight percent = basalt
Silica $\geq$ 53 and $<$ 58 percent = basaltic andesite
Silica $\geq$ 58 and $<$ 63 percent = andesite
Silica $\geq$ 63 and $<$ 68 percent = dacite
Silica $\geq$ 68 and $<$ 73 percent = rhyodacite
Silica $\geq$ 73 percent = rhyolite

EXPLANATION OF MAP UNITS

Surficial Deposits

Qal **Alluvium (Holocene and upper Pleistocene)**—Unconsolidated gravel, sand, and silt deposited in and adjacent to modern streams and flood plains. Channel gravels are composed of locally derived, angular to subangular clasts of rhyolite and dacite. Flood-plain and adjacent low-terrace deposits have developed 0.5- to 0.7-m-thick, silty loam soils

Qls **Landslide deposits (Holocene and upper Pleistocene)**—Unconsolidated mixtures of soil and rock formed by downslope movement following bedrock failure. Landslides are characterized by a hummocky surface with numerous springs. Most landslides in the quadrangle are ancient, currently inactive slides whose surfaces have been modified by erosion. Slides mostly occur where competent bedrock units overlie less competent clayey units. In the quadrangle, bedrock failure typically occurs where faults intersect contacts between competent lava flows and underlying clayey units. The clay zones are most common where glassy units have been altered by hydrothermal fluids ascending along faults

Qg **Glacial deposits (Pleistocene)**—Unconsolidated mixtures of cobbles, pebbles, sand, clay, and silt. Mainly outwash deposits of coarse gravel and silt. Includes small terminal and lateral moraines at 5,100-ft elevation on small, north-flowing tributaries of Sheep Creek

Qtg **Terrace gravels (Pleistocene)**—Unconsolidated to poorly consolidated gravel and sand deposits exposed in terraces along modern stream channels. Includes well-rounded, volcanic-clast gravel with clasts as large as 30 cm. Stranded by successive incision by the streams. Unit includes at least two terrace levels. Higher terrace deposits are exposed 70 m above Sheep Creek in the southwestern part of the quadrangle. Small terrace remnants are found 100 m above the flood plain on the landslide surface in the southeast quarter of section 23, T. 5 S., R. 35 E. Lower terrace deposits form benches 14 m above the flood plain surface adjacent to Sheep and Chicken Creeks. Terrace ages are poorly constrained, the terraces presumably record increased stream flow during glacial outwash periods

Columbia River Basalt Group

Tbcg **Grande Ronde Basalt (middle Miocene)**—Bluish-black, aphyric to sparsely plagioclase-phyric, holocrystalline lava flows. Consists of a flow-on-flow sequence of fine-grained lava flows that generally erode to orange-brown, angular clasts. Strata in uppermost exposures south of Fly Creek are tilted to the northeast, forming a gently sloping tableland mantled by colluvium and thin, unmapped fluvial gravel. Individual lava flows range from 15 to 30 m in thickness. Undulating contact with underlying units is locally marked by coarse gravel deposits. Unit is at least 80 m thick in northwest corner of map area. Iron-rich basaltic andesite geochemistry is typical of Grande Ronde basalt (Table 1, map no. 1). In thin section, Grande Ronde Basalt groundmass textures range from subophitic to intergranular. Map unit is volumetrically the largest unit of the Columbia River Basalt Group. Although assigned by Swanson and others (1981) to the R_2 magnetostratigraphic unit of the Grande Ronde Basalt, the flow interior of the sampled flow (Table 1, map no.1) displayed normal thermoremanent magnetism on a fluxgate magnetometer

Tower Mountain Volcanic Field

Lava flows, domes, and subvolcanic intrusions are part of a large lower Miocene to upper Oligocene volcanic center herein referred to as the Tower Mountain volcanic field. It forms a complexly interlayered sequence that underlies most of the quadrangle and is comprised mainly of silicic lava flows and domes. The Tower Mountain volcanic field is divided into the following units:

Tdjr **Dacite of Johnson Rock (lower Miocene)**—Sparsely plagioclase-phyric dacite that caps ridge in north-central part of the quadrangle at Johnson Rock. Unit is a bluish-gray, prominently flow-foliated, platy lava that typically weathers to a gray rock with a pronounced micaceous luster. Trachytic texture in thin section defined by aligned feldspar laths. Samples contain < 1 percent plagioclase phenocrysts and < 1 percent partially resorbed biotite phenocrysts that are less than 1 mm in diameter. Contains approximately 68 percent SiO_2 (Table 1, map no. 2). Emplaced as a single lava flow onto a highly irregular surface. The flow thins to the southeast from more than 140 m where exposed in the ridge east of Fly Creek. Early Miocene age based on whole-rock $^{40}Ar/^{39}Ar$ radiometric determination of 22.4 ± 0.16 Ma (R.A. Duncan, College of Atmospheric and Oceanographic Sciences, Oregon State University, written communication, 1997)

Tach **Andesite of Chicken Hill (lower Miocene or upper Oligocene)**—Flow-on-flow sequence of platy, gray andesite lava flows in the southeast corner of the quadrangle. Commonly platy jointed, weathering to whitish to pinkish-gray angular plates. Slightly porphyritic with 2–5 percent phenocrysts of plagioclase, hypersthene, and augite. Sequence is irregular in thickness and thickens eastward toward the Limber Jim Creek quadrangle (Ferns and Taubeneck, 1994). Unit includes andesite with ~ 60 percent SiO_2 (Ferns and Taubeneck, 1994)

Tdsc **Rhyodacite of Sheep Creek (lower Miocene or upper Oligocene)**—Massive, bluish-gray, porphyritic rhyodacite lava flow that caps the ridge east of East Sheep Creek. Characterized by chalky white plagioclase phenocrysts. Holocrystalline with between 5 and 10 percent phenocrysts 1–2 mm in diameter. Phenocrysts include plagioclase, hypersthene, augite, and rare quartz and potassium feldspar. Unit contains approximately 70 percent SiO_2 (Table 1, map no. 16). Thickness is variable; over 100 m of rhyodacite is exposed east of the confluence of the west and east forks of Sheep Creek. One measured sample displayed normal thermoremanent polarity

Twt **Welded ash-flow tuff (upper Oligocene)**—Light-gray, gray, and white, crystal-rich ash-flow tuff. Unit is about 80 ft thick and consists of two zones: an upper welded zone marked by light-gray tuff with subhorizontal flattened fiamme and a lower zone that is poorly exposed and consists of devitrified white to orange-white tuff. Welded zone is devitrified and contains 2–5 percent plagioclase phenocrysts < 2 mm in diameter and highly altered, skeletal green hornblende phenocrysts rimmed with opaque oxide minerals. Contains approximately 69 percent SiO_2 (Table 1, map no. 13). Although mapped only east of Sheep Creek, welded tuff float occurs below unit Tdsc near the headwaters of Chicken Creek

Tda **Porphyritic dacite lava flows (upper Oligocene)**—Massive, purplish-gray, flow-banded dacite lava flows that contain approximately 5 percent plagioclase phenocrysts as large as 2 mm in diameter. Small (< 1mm in diameter), partially resorbed biotite phenocrysts are visible in thin section. Includes underlying, 1- to 2-m-thick tuffaceous conglomerates and lithic breccias derived from underlying unit Tpa. Flows range from dacite to rhyodacite in composition (65–68 percent SiO_2) (Table 1, map nos. 8 and 9) and characteristically contain relatively higher amounts of potassium (> 3.0 percent K_2O) in comparison to other dacite and rhyodacite in the quadrangle

Tra **Aphyric rhyolite (upper Oligocene)**—White to yellowish-gray, flow-banded, platy, aphyric rhyolite exposed between Sheep Creek and Little Fly Creek. Interpreted as a flow-dome complex where dome margins are marked by steeply dipping, matrix- and clast-supported, tuffaceous rhyolite-clast breccia zones; complexly folded, flow-banded rhyolite lava; and massive, greenish-gray, partially devitrified perlite. Steeply dipping perlitic zones as much as 50 m wide contain lenses of massive pale reddish-brown and light-green lithophysal rhyolite. Dome interiors are marked by platy white rhyolite. In thin section, aphyric with partially zeolitized spherulites, groundmass of quartz, potassium feldspar, and plagioclase. Contains approximately 78 percent SiO_2 (Table 1, map no. 6)

Trp **Plagioclase-phyric rhyolite (upper Oligocene)**—White to yellowish-gray, flow-banded, platy porphyritic rhyolite, exposed on Chicken Creek. Commonly displays a mottled texture due to presence of 2–5 percent feldspar phenocrysts. Unit is interpreted as a flow-dome complex whose dome margins are marked by steeply dipping, thinly banded zones of lithophysae and vitrophyre. Open lithophysal cavities as large as 5 cm in diameter contain euhedral, terminated quartz crystals. Plagioclase phyric with 3 mm plagioclase and potassium feldspar phenocrysts with spherulites in a groundmass of quartz, potassium feldspar, and plagioclase. Contains approximately 78 percent SiO_2 (Table 1, map no.11)

Tob **Olivine basalt (upper Oligocene)**—Orange-weathering, bluish-black, porphyritic olivine-basalt and basaltic-andesite lava flows exposed stratigraphically below the rhyolite domes. Unit includes a holocrystalline flow with phenocrysts of plagioclase and olivine that crops out as a 25-m-thick lava flow beneath unit Trp on hill labeled with spot elevation 5,352 ft in sec. 9, T. 6 S., R. 35½ E. Unit also includes a holocrystalline lava flow with plagioclase, olivine, and augite phenocrysts in the southern part of the quadrangle. Analyzed samples are high-alumina basalt with approximately 48 percent SiO_2 and altered basaltic andesite with approximately 56 percent SiO_2 (Table 1, map nos. 12 and 20). Consists of small, areally restricted flows equivalent to those assigned to unit Tba of Ferns and Taubeneck (1994)

Tpa **Porphyritic lavas of Chicken Creek (upper Oligocene)**—Massive gray, purplish-gray, and bluish-gray, porphyritic-andesite and dacite lava flows. Individual flows commonly marked by coarsely plagioclase-phyric basal vitrophyre that grades up into massive, platy-jointed stony lava. Flow tops and margins marked by coarse, clast-supported breccia. At least three separate flows are exposed in the quadrangle, each containing as much as 15 percent phenocrysts as long as 7 mm and set in a variably altered, glassy groundmass. The northernmost flow, exposed along Sheep Creek, contains plagioclase, hypersthene, and augite phenocrysts. A massive and apparently overlying flow further south contains plagioclase, olive-green hornblende, and hypersthene phenocrysts. The stratigraphically highest flow, exposed east of Chicken Creek, contains plagioclase, quartz, hypersthene, and augite phenocrysts. Individual flows typically contain numerous—in places as much as 2 percent—crystalline inclusions of hypersthene, augite, and plagioclase. Composition ranges from high-silica andesite to dacite (63–68 percent SiO_2; (Table 1, map nos. 7, 15, and 18; see also analyses in Table 1 of Ferns and Taubeneck, 1994). Unit is more than 300 m thick, with individual flows as much as 100 m thick. Interbedded with pyroclastic deposits of unit Tpvs. Oligocene age based on radiometric date of 28.8 Ma (Fiebelkorn and others, 1982; recalculated from Walker, 1973) on a porphyritic hornblende-phyric andesite on Sheep Creek

Tpvs **Volcaniclastic rocks of Limber Jim Creek (upper Oligocene)**—Mainly debris-flow deposits interbedded with porphyritic dacite and andesite flows of unit Tpa. Unit consists of coarse, matrix- and clast-supported, tuffaceous breccia largely composed of angular to subrounded clasts of porphyritic andesite and dacite. Unit includes a gray or light-gray, hackly jointed, crystal-lithic, hornblende-bearing tuffaceous breccia with porphyry clasts as large as 12 in. in diameter. Consists mainly of poorly sorted, massive-bedded breccia exposed adjacent to massive exposures of lavas of unit Tpa. Includes primary debris-flow deposits associated with lava flows of unit Tpa. Locally includes medium-grained, tuffaceous conglomerates made up of rounded dacite, andesite, and rhyolite clasts. Unit thickens to the east, where over 225 m of interbedded breccias and tuffaceous conglomerates are exposed along Limber Jim Creek

Subvolcanic Intrusive Rocks

Tri **Rhyolite (lower Miocene and upper Oligocene)**—Mainly plagioclase-bearing rhyolite dikes that are locally columnar jointed. The dikes are white to light gray on fresh surfaces and weather to shades of light purple. Unit commonly contains as much as 5 percent plagioclase phenocrysts. Unit includes high silica rhyolite with 76 percent SiO_2 (Table 1, map no. 4). Intrusion exposed on Chicken Creek is cut by cryptocrystalline quartz seams < 1 mm thick

Tdi **Aphyric dacite (lower Miocene and upper Oligocene)**—Aphyric to slightly plagioclase-phyric, bluish-gray silicic andesite and dacite intrusions. Includes irregularly shaped, platy-jointed, subvolcanic intrusions. As mapped, includes at least three separate intrusions: northernmost intrusion exposed on Little Fly Creek centered on sec. 3, T. 6 S., R. 35 E., contains < 1 percent plagioclase and hypersthene phenocrysts 1–2 mm in length. Intrusion exposed on Sheep Creek in sec. 27, T. 6 S., R. 35 E., is aphyric, wheras the intrusive mass exposed on Chicken Creek in sec. 23, T. 6 S., R. 35½ E. contains < 1 percent clinopyroxene crystals 1 mm in diameter. Also includes narrow dikes on Chicken Creek that contain plagioclase and hypersthene phenocrysts. Intrusions are mainly dacite, with 66–68 percent SiO_2; but include andesite with ~57 percent SiO_2 (Table 1, map nos. 5, 14, 17, and 19). Thin argillic alteration zones and pyritic seams occur along small faults and joints in the large Chicken Creek intrusion

Tpi **Porphyritic rhyodacite (upper Oligocene)**—Dikes and small plugs of hornblende-phyric rhyodacite. Forms massive to columnar-jointed, gray to light-bluish-gray outcrops. Typically contains as much as 15 percent phenocrysts as much as 4 mm across. Phenocrysts include plagioclase, hornblende, hypersthene, and potassium feldspar. Analyzed sample is a rhyodacite with approximately 68 percent SiO_2 (Table 1, map no. 10)

Trq **Quartz rhyolite (upper Oligocene)**—Massive, white to yellowish-gray, porphyritic rhyolite exposed near the Grande Ronde River. Coarsely porphyritic, containing about 10 percent plagioclase and quartz phenocrysts as large as 5 mm in diameter. Less abundant, smaller (< 2 mm) phenocrysts include potassium feldspar (sanidine) and fayalitic olivine. Interpreted as a shallow intrusion in unit Tpvs—on the basis of an upper contact zone of intensely bleached, brecciated rhyolite. Chemically, a high-silica, peraluminous rhyolite with approximately 76 percent SiO_2 (Table 1, map no. 3)

Tbi **Basalt (upper Oligocene)**—Black to grayish-black, aphyric to glomeroporphyritic dikes. Includes a 100-m-wide dike in southwest corner of the map area. That dike contains plagioclase and clinopyroxene phenocrysts as well as glomerocrysts of plagioclase and clinopyroxene set in a trachytic groundmass of aligned feldspar laths. Dike strikes are roughly east-west

Pre-Tertiary Rocks

pTu **Pre-Tertiary rocks (Mesozoic and Paleozoic)**—Shown only in cross section and block diagram. Pre-Tertiary metamorphic rocks of the Baker terrane (Silberling and others, 1984) are inferred to underlie the quadrangle at shallow depths. Exposures in adjacent quadrangles include Triassic and Permian greenstones exposed in the Desolation Butte quadrangle at an elevation of 5,200 ft, approximately 2 mi of the southwest corner of the quadrangle (Evans, 1988), and at 4,300 ft, in the Limber Jim Creek quadrangle, about 0.8 km east of the northeast corner of the quadrangle (Ferns and Taubeneck, 1994). The greenstone exposures are included in the Bourne subterrane by Ferns and Brooks (1995) and have been intruded by younger Upper Jurassic to Lower Cretaceous tonalitic rocks. Small satellitic intrusions of the Bald Mountain Batholith are exposed along the Grande Ronde River at 4,400-ft elevation, 2 km east of the northeast corner of the quadrangle (Ferns and Taubeneck, 1994; Taubeneck, 1995)

STRUCTURE

Faults exposed in the quadrangle have short strike lengths and follow two dominant trends. Small-displacement, short-strike-length faults trend N. 65°–90° W. and parallel late-stage dikes in the Tower Mountain volcanic field. These earliest faults, which are in places mineralized, were formed during the later stages of Oligocene volcanism. A second group, which displays a dominant N. 20° E. trend, may also be volcanic related. These somewhat larger strike-length faults offset Oligocene volcanic units and control stream directions. They may be synvolcanic, as they run parallel to margins of the rhyolite domes of units Tra and Trp.

The short-strike-length faults in the northern part of the quadrangle cut the middle Miocene Grande Ronde Basalt with moderate vertical displacements. Individual faults can be traced for as much as 6 mi with as much as 130 m of vertical offset. The faults, with trends of between N. 40° W. and N. 65° W., form part of a regional-scale structure, herein referred to as the Fly Valley fault zone, that extends for over 50 mi across the southern half of the La Grande 1°×2° sheet. The Fly Valley fault zone is recognizable on images derived from the U.S. Geological Survey digital elevation model (DEM) and side looking airborne radar (SLAR) (EROS, 1990) as a narrow, N. 65° W.-trending downwarp about 5 mi wide. The course of the Grande Ronde River to the east in the Limber Jim Creek quadrangle is controlled by faults along the Fly Valley fault zone (Ferns and Taubeneck, 1994). Substantial vertical displacement across the Fly Valley fault zone is indicated by 400 m of down-to-the-south displacement of the base of the dacite of Johnson Rock in the northeast corner of the quadrangle.

Age of deformation along the Fly Valley fault zone is poorly constrained, and the structure may be a long-lived feature that has been reactivated periodically. The faults displace rocks as young as middle Miocene, but vertical displacements appear greatest in the older Oligocene volcanic units. Geomorphology in the northern part of the quadrangle is suggestive of relatively recent movement along the Fly Valley fault zone. Down-to-the-south faults along the north side of the Fly Valley zone mark the point where both Fly Creek and Grande Ronde River go from low-gradient (40–50 ft/mi over 5 mi in the upstream reaches), meandering streams in broad valleys to high-gradient (90–120 ft/mi over 5 mi in the downstream reaches) streams confined in narrow canyons. Location of knickpoints on both streams coincident with faults on the north flank of the zone may indicate more recent tectonism.

GEOLOGIC HISTORY

The Fly Valley quadrangle includes the eastern margin of a large, partially eroded, late Oligocene and early Miocene eruptive center. Volcanic rocks exposed in the quadrangle are a complexly faulted sequence of lava flows, domes, and shallow intrusions. Although equivalent in age (22–29 Ma) to the upper John Day Formation (28.8 Ma) (Robinson and others, 1990), the hornblende- and biotite-phyric Tower Mountain lavas are mineralogically closer to somewhat older (34–36 Ma) hornblende- and biotite-phyric calc-alkaline lava flows and shallow intrusions exposed to the south (Ferns and others, 1982; Hooper and others, 1995). The Tower Mountain rhyolites, which seldom contain sanidine, are more aluminous that the commonly sanidine-phyric rhyolite domes exposed in the western John Day Formation (Table 1).

Although not exposed in the quadrangle, pre-Tertiary metamorphic and intrusive rocks likely underlie the quadrangle at shallow depths. Nearby exposures include Permian and Triassic greenstone exposed at 5,200-ft elevation in the Desolation Butte quadrangle, approximately 3.5 km southwest of the quadrangle and at 4,300-ft elevation in the Limber Jim Creek quadrangle, 0.8 km east of the northeast corner of the Fly Valley quadrangle.

Volcanism in the quadrangle began approximately 28.8 Ma (Fiebelkorn and others, 1983; recalculated from Walker, 1973), when thick, highly porphyritic dacite and andesite flows (unit Tpa) were erupted from a broad area bordering the west side of the quadrangle. The vent area may be marked by rhyolite domes (unit Tra) in the west-central part of the quadrangle. The domes are roughly coincident with the east edge of a large gravity low (Figure 2) centered in the Tower Mountain quadrangle to the west. The rhyolite domes were apparently emplaced at about 28.1 ± 5 Ma, based on a K-Ar age determination (sample CC–1, Walker, 1973, recalculated by Fiebelkorn and others, 1983) on anorthoclase phenocrysts from a rhyolite dome on the southwest margin of the gravity low. A western source for the porphyritic lavas (unit Tpa) is indicated by the eastward thinning of the lava flows and the thickening of interbedded debris flows into the adjacent Limber Jim Creek quadrangle (Ferns and Taubeneck, 1994).

Eruption of small volumes of olivine basalt (unit Tob) and biotite rhyodacite (unit Tda) in the central part of the quadrangle began a period of rhyolite volcanism. Rhyolite dome fields (units Tra and Trp) formed with vertical feeders marked by narrow, steeply dipping zones of flow-foliated rhyolite, vitrophyre, perlite, and tuffaceous breccias. The dome fields were subsequently intruded by irregularly shaped masses of aphyric dacite and andesite (unit Tdi).

Calc-alkaline volcanism in the map area ceased after the eruption of thick, ridge-capping dacite (unit Tdjr) and andesite (unit Tach) lava flows about 22.4 Ma (isotopic age determination from the dacite of Johnson Rock). The Tower Mountain volcanic field stood as an eroded, faulted highland in the early and middle Miocene (~16 Ma), when flows of the Columbia River Basalt Group banked up against the highlands. These tholeiitic flood basalts, part of the Grande Ronde Basalt, were erupted from vents outside the quadrangle and flowed around the northern flank of the Tower Mountain volcanic field.

MINERAL, GEOTHERMAL, AND GROUNDWATER RESOURCES

Aggregate in the form of crushed rock for road building is the major mineral resource produced in the map area. Largest USFS quarries are located in the dacite intrusions (unit Tai). Most of the rock in the area is not mineralized, and the potential for both nonmetallic and metallic mineral resources is limited largely to rhyolite units Trp, Tra, and Trq.

A moderate resource potential exists for **precious-metal resources** in the wide alteration zones along unit Trp and unit Trq rhyolite dome margins that contain anomalous amounts of gold and mercury (Table 2). Although rhyolites cover much of the central part of the quadrangle, extensive hydrothermal alteration zones are found only along the margins of units Trp and Trq. No hydrothermal alteration zones were observed in the eroded central core areas of the rhyolites, where platy to massive, devitrified rhyolite is essentially unaltered. Analyses provided by the USFS show slightly anomalous levels of gold (as much as 31 ppb) and anomalous levels of mercury (150–36,800 ppb) in altered rock samples.

The largest alteration zone in the map area is located in SE¼ sec. 3, T. 6 S., R. 35½ E., where porphyritic rhyolite (unit Trp) has intruded porphyritic dacite flows (unit Tda), forming opalite and chalcedonic quartz masses in rhyolitic vitrophyre (unit Trp) over an area of about 40 acres. Alteration intensity increases from west to east; from a zone where the vitrophyre has been partially replaced by discontinuous pods of opaline quartz to a zone in which the vitrophyre has been completely converted to an iron-stained, massive, sugary quartz. Feldspars in the vitrophyre are altered completely. A second alteration zone is exposed along a logging road in sec. 17, T. 6 S., R. 35½ E., where thin stringers and seams of pyrite occur in an intensely silicified rhyolite porphyry dike. The rhyolite is exposed in a broad fault zone that cuts iron-stained and silicified rhyolite and andesite over a distance of 300 m. Unaltered hornblende dacite intrudes the north side of the fault zone. Pyrite stringers also ocur along fractures in altered dacite intrusive rocks exposed in a road cut on Chicken Creek, in section 14, T. 6 S., R. 35½ E.

Semiprecious gemstones in the form of thundereggs and precious opal may be found in rhyolite units Tra and Trp. Large gas cavities (lithophysae) partially filled with terminated quartz crystals locally form poor-quality geodes. Poor-quality thundereggs are found where opaline quartz fills small-diameter (< 5 cm) lithophysae in the central part of unit Tra. Thin seams of clear, amber to yellow opal were found in float pieces of an aphyric rhyolite breccia in sec. 15, T. 6 S., R. 35 E.

The aphyric rhyolite (unit Tra) contains perlitic zones that constitute a potential nonmetallic resource. Steeply dipping zones of **perlite** 15 m wide are exposed in the southwest corner of sec. 11, T. 6 S., R. 35 E. The perlitic zones are separated by a steeply dipping, flow-banded stony rhyolite that contains lithophysae. Most of the perlite contains clots and seams of devitrified rhyolite.

The rhyolite domes (units Tra and Trp) are sources of **stone** that has been used locally as a decorative facing stone. Devitrified rhyolite cores are white to pale yellow and commonly platy jointed. Although the surface material weathers to thin, brittle plates, better indurated material may occur below the weathered surface.

Low-temperature **geothermal resources** may be present in the quadrangle. Hampton and Brown (1964) reported a temperature of 83°F at the warm mineral spring near Sheep Creek in NW¼ sec. 10, T. 6 S., R. 35 E. The spring has a sulfurous odor and issues from fractures along an east-west fault.

As noted by Hampton and Brown (1964), the Oligocene volcanic rocks exposed over most of the quadrangle are relatively impermeable and are expected to act as part of the regional hydrologic basement. The silicic lavas are platy jointed, glassy, and, along fault zones, commonly altered to impermeable clays. Volcaniclastic

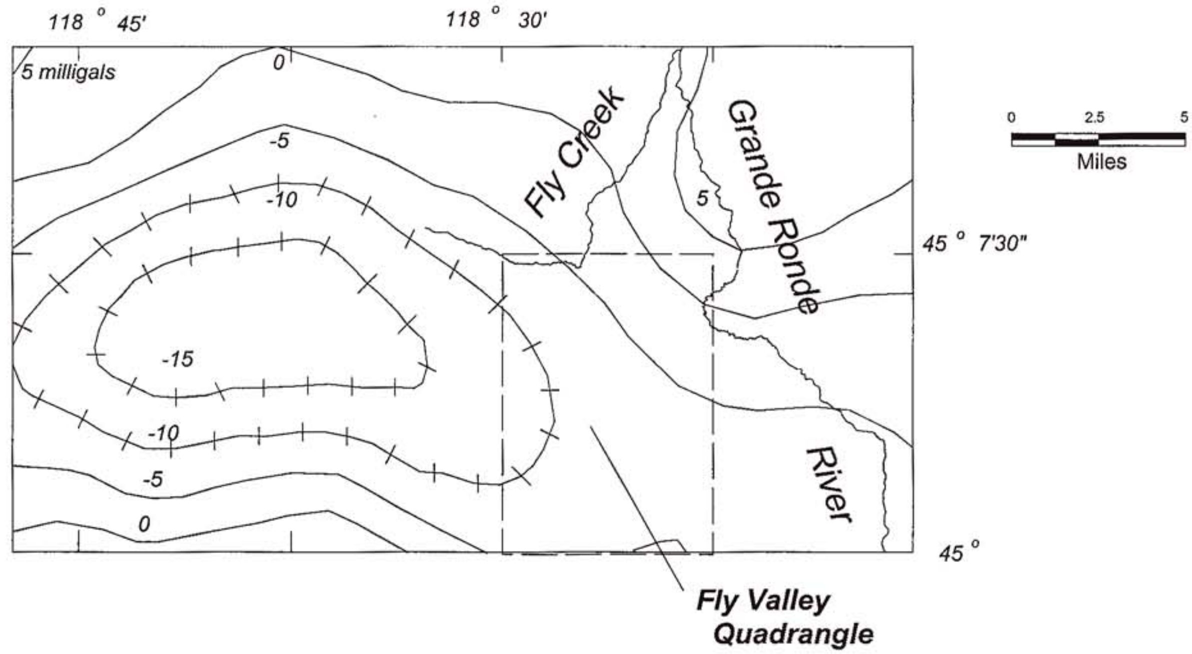

Figure 2. Regional isostatic map, showing large gravity low west of the Fly Valley quadrangle. Contour intervals are 5 milligals. Contours taken from unpublished regional (scale 1:500,000) isostatic gravity map by M. Dean Kleinkopf, U.S. Geological Survey, Denver, Colorado.

breccia and conglomerate (unit Tpvs) contain a high proportion of volcanic glass that has been altered to impermeable clay minerals. Most of the observed springs are in broken rock, either in faults or landslides. It is unlikely that substantial amounts of **groundwater** are contained in the Quaternary alluvium; bedrock is likely shallow, as indicated by the low bedrock hills that protrude through the alluvial cover. As even the smallest streams flow year-round, the amount of subsurface flow through the basement rocks is likely relatively small.

GEOLOGIC HAZARDS

Landslides are the most obvious geologic hazard noted in the Fly Valley quadrangle. The landslides are nearly always spatially associated with faults, occurring either where faulting has exposed relatively incompetent tuffaceous volcaniclastic rocks (unit Tpvs) beneath massive dacite and andesite lava flows or along fault zones that contain clays formed by hydrothermal alteration.

The largest landslide is located along a fault in the northeast corner of the quadrangle south of Johnson Rock, where tuffaceous breccia (unit Tpvs) is exposed beneath a large dacite lava flow (unit Tdjr). Geomorphology of the landslide deposit suggests that it has developed over time, parts of it being periodically reactivated. Although the upper part of the landslide deposit retains the hummocky topography and numerous springs characteristic of a relatively young landslide, the lower, older slide surface is in places dissected and overlain by a thin veneer of high-terrace gravels.

Some of the smaller landslide deposits are currently active and, during periods of high runoff, produce mudflows that bury the East Sheep Creek road. The active mudflows on East Sheep Creek issue from the toe of a larger, older landslide deposit that originated along the contact between a porphyritic andesite lava flow (unit Tpa) and an underlying wedge of volcaniclastic sediment (unit Tpvs).

Although some of the clay alteration zones also form small landslides, they may be of greater concern as point sources for certain types of **trace metals**, including mercury and arsenic. The alteration zones contain as much as 38 ppm mercury and 40 ppm arsenic (Table 2). Soils and sediment derived from these zones are likely to contain elevated levels of mercury and arsenic.

On the basis of geologic data collected to date, the **seismic hazard** associated with the Fly Valley fault zone appears relatively small. Although the zone is a major geologic feature that controls knickpoints on Fly Creek and the upper Grande Ronde River, there are no scarps of clearly Quaternary age along any faults within the zone. Since evidence of historic seismicity is lacking, the Fly Valley fault zone is probably currently inactive.

ANALYTICAL METHODS

Analyses for Table 1 were performed by X-ray fluorescence (XRF) with the automatic Rigaku 3370 spectrometer of the Washington State University GeoAnalytical Laboratory. Each element analysis is fully corrected for line interference and matrix effects. Results have been normalized on a volatile-free basis and calculated with total iron expressed as FeO. See Hooper and others (1993) for a more complete description of Washington State University GeoAnalytical Laboratory analytical methods.

Analyses for Table 2 were performed by SVL Analytical, Inc., Kellogg, Idaho. Concentrations were determined by several different processes: gold and silver by atomic absorption with a fire assay preconcentration; mercury by cold-vapor atomic absorption; arsenic, selenium, and antimony by graphite furnace-atomic absorption; and the other elements, molybdenum, copper, lead, zinc, and tin, by induction coupled plasma (ICP).

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Table 1. Geochemical analyses, unaltered rocks, Fly Valley quadrangle, Union County, Oregon[1] (continues ➤)

Map no.	Field/ Lab no.	UTM coordinates	¼	¼	Sec.	T. (S.)	R. (E.)	Elev. (ft)	Map unit	Lithology	SiO_2 %	Al_2O_3 %	TiO_2 %	FeO* %	MnO %
1	96-LG-100	385530E4997540N	NE	NW	20	5	35	4,460	Tbcg	Basalt	55.03	14.01	2.222	11.42	0.206
2	96-LG-130	389060E4995240N	SW	NE	27	5	35	4,510	Tdjr	Dacite	68.03	16.71	0.686	3.81	0.023
3	96-LG-129	389810E4994870N	NW	SW	26	5	35	4,280	Trq	Rhyolite	76.38	16.04	0.413	0.42	0.002
4	96-LG-60	382560E4990810N	SE	NW	10	6	35	4,980	Tri	Rhyolite	76.88	13.43	0.146	0.37	0.003
5	96-LG-3	383670E4991450N	SE	SE	3	6	35	5,160	Tdi	Dacite	66.27	17.26	0.883	3.13	0.032
6	96-LG-132	385020E4990840N	SE	NE	11	6	35	4,640	Tra	Rhyolite	78.25	13.37	0.092	0.38	0.017
7	96-LG-131	388020E4991230N	SE	SE	4	6	35.5	4,700	Tpa	Dacite	66.81	16.39	0.806	3.51	0.038
8	96-LG-74	388800E4991690N	NE	SW	3	6	35.5	4,420	Tda	Dacite	68.37	15.46	0.505	4.62	0.077
9	96-LG-73	389260E4992180N	NW	NE	3	6	35.5	4,340	Tda	Dacite	65.45	16.92	1.336	3.76	0.043
10	96-LG-22	389350E4992450N	NW	NE	3	6	35.5	4,300	Tpi	Dacite	68.02	17.47	0.585	4.03	0.040
11	96-LG-133	389770E4990890N	SE	SE	3	6	35.5	4,320	Trp	Rhyolite	78.50	12.14	0.146	0.26	0.000
12	96-LG-25	387550E4989240N	SE	SW	9	6	35.5	5,060	Tob	Basalt	48.54	17.98	2.395	9.21	0.158
13	96-LG-17	386240E4988790N	NW	SE	13	6	35	5,080	Twt	Welded tuff	69.71	16.06	0.422	2.83	0.025
14	96-LG-83	382840E4986290N	NE	NW	27	6	35	4,940	Tdi	Dacite	67.92	16.46	0.533	3.21	0.051
15	96-LG-21	385270E4986800N	SE	SE	23	6	35	5,340	Tpa	Dacite	64.26	16.61	0.848	4.79	0.056
16	96-LG-18	385690E4986980N	NE	SW	24	6	35	5,660	Tdsc	Rhyodacite	70.29	15.04	0.437	2.78	0.037
17	96-LG-46	389800E4986770N	NE	NE	22	6	35.5	4,940	Tdi	Andesite	56.71	17.57	1.083	7.61	0.107
18	96-LG-135	391230E4986120N	SW	SW	24	6	35.5	4,940	Tpa	Dacite	63.66	16.30	0.714	5.17	0.153
19	96-LG-134	391280E4985850N	NW	NW	25	6	35.5	5,100	Tdi	Dacite	68.24	17.05	0.611	2.43	0.034
20	96-LG-102	389670E4984200N	NE	NE	34	6	35.5	5,720	Tbi	Andesite	56.67	15.73	0.844	6.94	0.141
—[2]	95-BE-31	—	NE	NW	6	13	13	3,560	—	Rhyolite	78.60	10.92	0.125	1.63	0.01

[1] All analyses done by XRF by the Washington State University GeoAnalytical Laboratory.

[2] Rhyolite sample from the western John Day Formation, for comparison purposes only.

Table 2. Geochemical analyses of altered rock samples, Fly Valley quadrangle[1] (continues ➤)

Map no.	Field/ Lab no.	UTM coordinates	¼	¼	Sec.	T. (S.)	R. (E.)	Elev. (ft)	Map unit	Lithology
A	96-LG-10	4995160N390120E	NW	NW	26	5	35	4,380	Trq	Rhyolite
B	96-LG-31	4991020N389200E	SW	SE	3	6	35	4,600	Trp	Rhyolite
C	93-BG-27	4990870N389720	SE	SE	3	6	35	4,320	Trp	Rhyolite
D	96-LG-78	4990080N389880E	SE	NE	10	6	35	4,480	Tpa	Dacite
E	96-LG-30	4988490N387440E	SE	NW	16	6	35	5,060	Tpa	Dacite
F	93-BG-26	4988490N390620E	SE	NW	14	6	35	5,580	Tdi	Dacite
G	96-LG-40	4986680N387130E	NW	SW	21	6	35	4,520	Trp	Rhyolite

[1] See text for explanation of analytical procedures; n.a. = not analyzed for this element.

Table 1. Geochemical analyses, unaltered rocks, Fly Valley quadrangle, Union County, Oregon (final section)

CaO %	MgO %	K_2O %	Na_2O %	P_2O_5 %	Ni ppm	Cr ppm	Sc ppm	V ppm	Ba ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ga ppm	Cu ppm	Zn ppm	Pb ppm	La ppm	Ce ppm	Th ppm
7.91	4.03	1.53	3.22	0.416	6	35	32	371	612	34	315	36	161	15.2	23	30	121	6	23	47	6
4.03	0.16	1.89	4.41	0.251	9	14	13	56	788	22	584	18	200	16.5	23	11	82	7	20	48	4
0.55	0.04	3.66	2.46	0.034	11	12	5	45	543	93	127	19	132	19.8	18	5	11	8	25	47	9
0.65	0.26	4.57	3.66	0.024	9	0	5	14	794	92	61	17	139	18.7	16	8	22	12	36	57	9
4.96	1.27	1.75	4.21	0.239	19	21	14	95	773	40	462	20	161	14.9	17	19	35	8	25	33	5
0.33	0.29	5.68	1.56	0.023	13	0	3	0	1415	107	46	19	97	16.7	14	5	3	10	19	42	10
4.43	1.58	2.16	4.07	0.196	28	40	13	84	714	49	355	16	152	14.7	19	25	60	8	9	60	4
2.60	0.36	3.14	4.73	0.150	5	4	9	6	844	53	296	35	334	41.0	26	1	115	9	45	86	5
3.85	0.24	3.04	4.81	0.549	5	4	12	110	893	52	404	35	339	43.0	29	8	156	9	28	70	7
3.26	1.14	1.47	3.83	0.154	13	7	8	68	1022	18	366	29	131	13.0	17	18	53	7	23	29	2
0.25	0.03	5.01	3.65	0.018	11	0	1	2	1062	96	50	25	336	50.0	26	3	24	9	26	41	9
10.27	7.19	1.03	2.83	0.398	72	92	24	240	225	11	571	22	174	27.1	22	41	86	0	14	65	0
4.02	0.70	1.85	4.22	0.152	14	13	9	46	856	28	520	22	144	13.0	20	11	54	8	29	39	4
5.47	1.59	0.79	3.84	0.151	29	39	12	73	413	16	488	15	133	9.1	19	13	52	6	3	35	3
4.62	2.85	2.05	3.73	0.196	44	40	16	55	736	26	420	17	141	16.0	18	25	56	6	21	55	2
3.29	1.13	2.91	3.98	0.104	25	38	11	59	794	62	378	19	136	14.5	18	19	51	10	10	56	3
8.12	4.10	0.97	3.54	0.185	45	51	21	169	487	17	453	18	104	11.6	18	39	74	2	0	29	3
5.21	2.93	1.75	3.95	0.180	63	104	15	108	610	36	432	14	125	12.4	19	31	59	7	20	22	6
4.83	0.91	1.88	3.85	0.164	16	25	9	84	847	40	474	14	127	10.5	20	15	48	9	6	47	4
8.73	6.16	1.13	3.44	0.214	151	248	20	146	451	20	576	15	106	10.1	15	65	64	5	18	42	3
0.12	0.16	5.01	3.41	0.026	9	0	0	4	309	172	14	99.0	373	49	30	2	111	14	81	130	15

Table 2. Geochemical analyses of altered rock samples, Fly Valley quadrangle (final section)

Sb ppm	As ppm	Cr ppm	Co ppm	Au ppb	Hg ppb	Pb ppb	Ag ppb	Zn ppb	Se ppb	Sn ppb
31	12	n.a.	n.a.	31	36,800	11	<0.1	13	<0.5	<15
1	11	n.a.	n.a.	<5	186	12	<0.1	8	<0.5	<15
1	6	59	8	16	1,530	12	1.5	38	n.a.	n.a.
2	6	n.a.	n.a.	<5	589	7	<0.1	43	<0.5	<15
<0.5	3	n.a.	n.a.	7	153	18	<0.1	19	<0.5	<15
2	42	151	1	14	648	5	1.6	35	n.a.	n.a.
<0.5	2	n.a.	n.a.	<5	1,890	6	<0.1	7	<0.5	<15