State of Oregon
Department of Geology and Mineral Industries
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OPEN-FILE REPORT
O-06-11

PRELIMINARY GEOLOGIC MAP OF THE SEXTON MOUNTAIN, MURPHY, APPLEGATE, AND MOUNT ISABELLE 7.5′ QUADRANGLES, JACKSON AND JOSEPHINE COUNTIES, OREGON

By

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2006

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Oregon Department of Geology and Mineral Industries Open File Report
Published in conformance with ORS 516.030

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TEXT TO ACCOMPANY PRELIMINARY GEOLOGIC MAPS OF THE SEXTON MOUNTAIN, MURPHY, APPLEGATE, AND MT. ISABELLE QUADRANGLES, JACKSON AND JOSEPHINE COUNTIES, OREGON

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EXPLANATION OF MAP UNITS

Surficial Deposits

Qm **Mine tailings overlay (Historic)-**Boulder to pebble gravel, sand, silt, and clay redistributed by mining. Includes bedrock areas too small to show. The distribution of mine tailings shown here has been modified from Josephine and Jackson County soil maps (SCS, 197?, 197?). However, the true distribution of ground disturbed by placer mining is much more extensive, especially along smaller streams that cut meta-sedimentary and meta-volcanic bedrock. Streams that have been placer mined typically have canyons with abnormally flattened or hummocky bottoms and steep-walled sides. These features resulted from miners removing alluvium or colluvium to expose the gold-bearing gravel that lies just above bedrock. Hummocks typically consist of small bedrock highs, piles of hand-sorted boulders and cobbles, or dredge spoils. Undisturbed valleys in the map area usually have v-shaped to concave-upward cross sections. In contrast, mined valleys are typically box- or u-shaped with steep walls from 3 to 30 m (10-100 ft) high. In most of these areas, the pre-mining slopes were likely similar to those lying just uphill from the tops of the steep cuts made by the miners. Large volumes of alluvium, colluvium, and weathered bedrock were displaced by hydraulic mining and dredging. Sand and pebble gravel mobilized by 19th and early 20th century placer mining undoubtedly wound up in alluvial fans and fluvial deposits, including those found along slopes and small tributary streams located high on the sides of larger valleys. In most areas, later floods have mixed the bulk of fine-grained mine tailings (pebbles and smaller) into the natural system where they are depicted in other surficial units.

Qya **Young alluvium (Holocene)-** Gravel, sand, and silt along channels and flood plains of modern streams.

Qoa **Older alluvium (Holocene and upper Pleistocene)-**Gravel, sand, and silt deposits outside the limits of active channels and low-lying flood plains.

Qal **Alluvium undivided (Holocene and Pleistocene) -**Unconsolidated to semi-consolidated sand, gravel, silt, mud, and clay deposited along streams. Less mature sediment with local provenance occurs along smaller streams. The provenance contrast between alluvium deposited by streams draining areas with granitic bedrock (dominated by coarse quartzo-feldspathic sand) and those with metamorphic bedrock (dominated by metamorphic pebbles) is striking. The more subtle contact between granitic alluvium and weathered granitic bedrock may be difficult to pinpoint in the field or in driller's water well logs. Logs reporting pebbles, sticks, sorting, and "heavy" (pronounced *hee' vee*; an indication of liquifaction) granite all suggest the presence of granitic alluvium.

Qaf **Alluvial Fan Deposits (Holocene and Pleistocene) -** Gravel, sand, and silt in individual or coalescing fan-shaped deposits along valley margins. Typically occur where gradients of tributary streams decrease abruptly at valley floor levels of larger stream. In contrast to alluvium deposited by larger streams, clast make-up reflects local provenance. Angular to sub-rounded grains and clasts are common.

Qls **Landslides (Holocene and Pleistocene) -** Fragments of bedrock mixed with gravel, sand, silt, or clay and displaced downslope by gravity sliding. Includes slumps, earthflows, block glides, debris flows and rockfalls.

Qt **Terrace Deposits (Pleistocene) -**Unconsolidated to semi-consolidated gravel, sand, and silt deposits preserved as eroded remnants of older surficial deposits. Commonly preserved along the larger valleys as terrace remnants that lie well above the modern floodplain. May also fill valleys beneath younger surficial units. May be blanketed by younger colluvium and small alluvial fans along valley edges, or overlain by a thin veneer of alluvium along streams. Can often be distinguished from younger units by weathered clasts and better soil development. In places only chemically resistant clasts such as those composed of vein quartz can be easily distinguished from red clay soils produced by weathering.

UNCONFORMITY

Cretaceous Sedimentary Rocks

Khss **Hornbrook Formation (Upper Cretaceous, late Albian to Cenomanian)-** Primarily marine sandstone with lesser siltstone, pebbly sandstone, and pebble conglomerate. Crops out as isolated ridge top exposures and down-faulted blocks in the eastern part of the Mount Isabelle quadrangle. Beds immediately above the basal unconformity may be non-marine. These beds often contain, or are wholly composed of, angular to sub-rounded clasts and grains derived from nearby Jurassic rocks. Within a few meters of the unconformity the Hornbrook Formation sandstone and pebbly sandstone beds become micaceous and arkosic and many pebbles are well rounded and far traveled. Thick beds of micaceous sandstone near the base of the formation often contain ovoid sandstone concretions up to two meters in diameter. In contrast to Jurassic sandstone, these rocks are often friable, with open pore space between undeformed, rounded sand grains. The formation is locally fossiliferous. Valves of the robust, knobby-ribbed pelecypod *Trigonia* are common, occurring singly or as layers in sandstone and pebbly sandstone. The outcrops mapped in this report form part of Sliter and others (1984) “Dark Hollow Area”. They report that fossils collected nearby range in age from late Albian to Turonian. Although none of their fossil collections are from exposures mapped in this study, bedding generally parallels the underlying unconformity and it seems likely that the lower horizons they collected are equivalent to those mapped here. Those rocks range in age from late Albian to Cenomanian. Bedding and the unconformity define an eastward-tilted remnant of Late Cretaceous ocean floor. Although not recognized here, Wiley and Smith (1993) reported limy sandstone beds at the base of the formation one mile to the east of the study area in the Medford West quadrangle. Farther north and east the Hornbrook Formation is overlain by Eocene non-marine sandstone of the Payne Cliffs Formation (Wiley and Smith, 1993).

UNCONFORMITY

Jurassic Rocks

Jss **Shale of Sunny Valley of Smith and others (1982), (Late Jurassic?)-**Spotted slate and shale with minor sandstone, pebbly sandstone, and psammite. Crops out immediately beneath serpentinite-matrix melange. Lower contact is at least locally depositional on intermediate to mafic volcanic and intrusive rocks in the vicinity of the Copper Queen Mine to the west of Interstate Highway 5. Metamorphic grade appears to increase towards adjacent thrust contact with structurally overlying Greenback Melange.

Greenback Melange, Sexton Mountain Ophiolite of Smith and others (1982), and related rocks

This group of rocks includes: 1) serpentinite-matrix melange structurally overlain by, 2) mafic intrusive to extrusive rocks that Smith and others (1982) assigned to their Sexton Mountain ophiolite, 3) sedimentary and volcanic sequences that crop out east of, and locally on, the ophiolite sequence, and 4) remobilized serpentinite that crops out as lenses and septa along fault zones. Rocks representing deeper levels of the ophiolite are typically metamorphosed to greenschist, epidote-amphibolite, or amphibolite facies. These observations are consistent with seafloor metamorphism occurring near a spreading center.

Jgm **Greenback Melange (Jurassic)-**Serpentinite matrix tectonic melange lies structurally beneath the ophiolite but is probably somewhat younger. It contains blocks of peridotite (unit **ghz**), gabbro (unit **gg**), mixed diabase and gabbro (unit **gdg**), diabase (unit **gd**), basalt (unit **gb**), andesite (unit **gv**), chert (unit gc), and tuffaceous shale, phyllite, and argillite (unit **gss**). Blocks range in size from 10 centimeters to more than a kilometer. They are typically elongate with long axes parallel to the upper and lower contacts of the melange. Sexton Mountain itself appears to be a partly dismembered, perhaps even overturned, block of ophiolite. A large block of dunite (unit **gdu**) makes up the southwestern flank of Walker Mountian. To the east the melange is in fault contact with the Sexton Mountain Ophiolite and, north of the map area, with volcanic and sedimentary rocks that overlie the ophiolite, and with rocks assigned to the May Creek Schist. Jurassic(?) shale, tuff, volcanic, and related rocks crop out beneath the melange to the west. The Jurassic age of the melange assumes that it post-dates formation of the Middle Triassic to Lower Jurassic Sexton Mountain Ophiolite on the basis of similar lithologic associations. Rocks immediately west of the fault zone are not well dated; the nearest dated rocks, 12 km to the west-southwest, contain the pelecypod *Buchia concentrica* (Late Jurassic, Oxfordian-Kimmeridgian, ca. 150-160 Ma) in beds that crop out along Merlin-Galice Road near Morrison's Lodge. The *Buchia* bearing beds are separated from the shale sequence that underlies the Greenback Melange by a band of serpentinite, gabbro, and basalt at Hellgate Canyon and, presumably, a major fault. Two blocks in the melange have yielded some age information. Jesse Grady (UNLV, personal communication) reports a 177 Ma U-Pb date for zircon collected from a hornblende-pegmatite dike in a gabbro block on the west side of Sexton Mountain. Irwin and Blome (2004) report Early Jurassic (Sinemurian and Pleinsbachian) radiolaria from a tuffaceous shale at the headwaters of Boulder Creek in the King Mountain quadrangle to the northeast. This radiolaria locality lies close to the contact between the melange and the sedimentary sequence that lies above the ophiolite. There is a possibility that the dated rocks are from the sedimentary sequence that overlies the ophiolite rather than in the Greenback Melange. Massive sulfide accumulations in shale occur nearby in the same unit that contain the radiolaria, suggesting an affiliation with the top of the ophiolite. The contact between the two formation is largely buried by Cretaceous sandstone in this area. In contrast to the Rattlesnake Creek terrane melange, there are no reports of limestone from the Greenback melange. Other possible constraints on the age of the melange include Harper and ???'s, (199?) report of syntectonic intrusion of the 139 Ma Grants Pass pluton. The melange hosts a large number of gold mines including the Greenback Mine which was at one time the second largest mine in Oregon.

Jvs **Volcaniclastic and Volcanic Rocks (Lower to Middle Jurassic)-**Greenstone, meta tuff, and tuffaeous sedimentary rocks. Locally contains talc lenses. Tuffaceous shale block assigned to the Greenback Melange unit contains radiolaria dated as Early Jurassic (Pleinsbachian-Sinemurian; Irwin and Blome, 2004). At least three intervals of volcanic and volcaniclastic rock occur in the Spencer Creek area in the Murphy quadrangle. The two lower zones are predominantly lava flows; the upper zone includes volcaniclastic rocks.

Js **Sedimentary rocks (Lower to Middle Jurassic)-**Phyllite, slate, quartzite, psammite and stretched pebble conglomerate. Lenses of meta-chert, massive sulfide, and tuffaceous sediment occur along the contact with unit JTb. Conglomerate contains scattered quartzite clasts and may record juxtaposition of ophiolite sequence with rocks to the east. Marble is present but rare. Two thick intervals of sedimentary rock, separated by lava flows (unit Jvs), are recognized in the Spencer Creek area of the Murphy quadrangle. In the Ditch Creek area east of the Sexton Mountain quadrangle these rocks are unconformably overlain by Cretaceous sandstone referred to as the Grave Creek Beds of the Hornbrook Formation by Sliter and others (1984).

JTb **Mafic flows and dikes (Middle Triassic to Lower Jurassic)-**chemistry and textures suggest original compositions ranged from andesite to basalt, locally porphyritic. Seem to have originated as flows (typical near the contact with unit Js) or shallow(?) dike and/or sill complexes (typical near the contact with unit JTd). May contain lesser amounts of other metamorphosed volcanic and sedimentary lithologies. Pillow basalt was not recognized. Metamorphism is epidote-amphibolite to greenschist facies.

JTdm **Diabase and basalt (Middle Triassic to Lower Jurassic)--**Fine- to medium-grained mafic intrusive rocks. Locally occur as layered dikes.

JTdc **Diabase, gabbro, and basalt (Middle Triassic to Lower Jurassic)-** this unit displays a characteristic mixing of crystal sizes ranging from basalt (<1 mm) to gabbro (>2 mm) that is present even in small outcrops of less than a square meter. Indurated spheroids of coarser crystals (typically 0.3 to 1 meter in diameter) surrounded by more easily weathered finely crystalline zones are common. In places they have the appearance of landslide deposits. The spheroids Mixed crystal sizes, spheroids, dikes, sills, and banding are interpreted as a complex intrusive fabric that formed near the top of a mafic magma chamber. These rocks have experienced greenschist to epidote-amphibolite facies metamorphism.

JTg **Gabbro (Middle Triassic to Lower Jurassic)-**metamorphosed pyroxene and plagioclase gabbro with minor cumulate gabbro near the contact with unit JTrgc. Minor diabase dikes more common near the contact with unit JTrd. Pyroxene largely replaced by amphibole. Hornblende pegmatite dike in large gabbro block at Sexton Mountain (mapped here as part of the Greenback Melange unit) dated at 177 Ma by Grady (note similarity to hornblende ages from so-called Western Hayfork terrane of Donato and others (199?). Locally layered pyroxene-plagioclase gabbro ranges in composition from pyroxenite to anorthosite. Pyroxene locally replaced by amphibole. Occurs along the margins of unit JTg.

Broken Formation: Metamorphosed Sedimentary, Volcaniclastic, and Volcanic rocks

This sequence of rocks is exposed in a NNE-trending band that underlies much of the Murphy, Applegate, and Mt. Isabelle quadrangles. Rocks are deformed and sheared with many small faults along bedding planes. However, transitional facies were recognized at several contacts. These include sandstone (quartzite) and phyllite with enclosed blocks and boulders of marble at marble/sandstone and marble/phyllite contacts. In places, graded beds interpreted as turbidites have volcanic sands in the larger grain sizes (Bouma a and b intervals) and quartzite in the finer grain sizes (Bouma b and c(?) intervals) indicating that volcanic and quartz/chert sources contributed sediment to the basin simultaneously. Where recognized, sandstone-shale sequences are generally similar to those recognized on the middle to upper parts of submarine fans. These include thick sections of massive to parallel laminated sandstone in amalgamated beds (Mutti-Ricci Lucchi facies B) and interbedded 0.5 to 3 m thick sandstone and phyllite beds with sandstone:phyllite ratios greater than 1 (Mutti-Ricci Lucchi facies C). In places (or at times?) provenance changes from volcanic and volcaniclastic sands to quartz (chert?) sands. This suggests that juxtaposed lithologies reflect, at least in part, original relations. These rocks are interpreted as lapping across several blocks in the underlying melange. Alternative interpretations include that of a large block in a regional block-on-block melange and that of an exotic terrane (Western Hayfork terrane) that overlies such a melange.

JTs **Sedimentary rocks (Middle Jurassic to Lower Triassic)** -Predominantly siliciclastic sedimentary rocks. Probably includes unmapped areas of volcanic and volcaniclastic rock and schist. Includes the following lithologies not mapped separately:

Phyllite, slate, and argillite-Fine grained, dark gray to black clastic strata with lesser amounts of sandstone and siltstone.

Quartzite-Interbedded quartz sandstone and siltstone with lesser amounts of phyllite/slate/argillite. Also includes laminated and banded quartzite interpreted as metachert.

Volcanic sandstone-Interbedded sandstone, siltstone, and shale (phyllite/slate/argillite). Volcanic sandstone is distinguished from volcaniclastic rocks of unit JTrvs by the predominance of rounded grains, by grain support, or by disequillibrium provenance. Sandstone beds with disequillibrium provenance have grain suites inconsistent with derivation from magmas in chemical/mineralogical equilibrium. For example, a single sandstone bed containing both high aspect ratio igneous hornblende (wet magma) and equant hornblende pseudomorphs after augite (dry magma).

Lithic sandstone and pebbly sandstone-sandstone and pebbly sandstone with grains and clasts flattened to aspect ratios generally greater than 3:1 in sections perpendicular to bedding/foliation.

Marble, silicified marble, and dolomite-massive, banded, or laminated, generally coarsely crystalline. At least some contacts are depositional as seen a few kilometers to the north of the study area at the Gold Hill quarry. There large blocks and boulders of marble form clasts in adjacent (overlying?) quartzite and phyllite beds to the east. Outcrops of marble can only rarely be followed more than a few hundred meters. However, taken together, the individual exposures define bands of marble-bearing sedimentary rock that extend for up to 10 km along strike. Several quarries expose antiforms and synforms that indicate the marble (and presumable the enclosing meta-sedimentary rock) is tightly folded. In several places marble overlies lava flows. This suggests that environments favorable for limestone deposition were isolated from clastic sediment sources, in this case by elevation above the surrounding sea floor. The presence of discontinous marble lenses along stratigraphic horizons extending many kilometers suggests larger-scale variation in sediment supply, sea level, ocean chemistry, or temperature. Similar relationships are reported for marble and related lithologies at Oregon Caves 25 km to the south-southwest.

JTvs **Volcaniclastic rocks (Middle Jurassic to Lower Triassic)-** interpreted as primary eruptive products deposited by sediment-gravity flows. Typically contains abundant euhedral to subhedral crystals of augite and plagioclase that form angular to sub-angular sand grains and very fine pebbles. Equant magmatic augite is often partly or completely replaced by pseudomorphs of metamorphic hornblende. Interpreted as volcaniclastic rather than sedimentary where provenance is generally consistent with an equilibrium magma, where crystals are euhedral to subhedral, and where crystal size and sorting appears to reflect magmatic history rather than erosion and transport. Includes unmapped interbeds and sequences of volcanic and sedimentary rocks and schist. Includes the following lithologies:

Augite-plagioclase sandstone-metamorphosed volcanic sandstone with euhedral to subhedral crystals (particularly mafic crystals), small percentage of lithic fragments, may be matrix supported, provenance generally consistent with sands derived from an augite and plagioclase phyric magma.

Augite-plagioclase sandy mudstone

JTv **Volcanic rocks (Middle Jurassic to Lower Triassic)-**Flows and amygdaloidal or vesicular flows of intermediate to mafic composition. Groundmass textures are typically obscured by metamorphism.

Other Intrusive Rocks

Kgp **Grants Pass Pluton (Early Cretaceous; 139 Ma)-**hornblende-biotite granodiorite. Locally divided to show diorite of unit **Kgpd** along the margins of the pluton

KJi **Granodiorite and quartz-diorite intrusions (Jurassic to Early Cretaceous)-**hornblende-, biotite-, and hornblende-biotite-granodiorite and quartz diorite.

KJd **Diorite (Middle Jurassic to Early Cretaceous)-** hornblende and hornblende-biotitediorite.

KJt **Timber Mountain Pluton (Jurassic to Early Cretaceous)-**hornblende-biotite granodiorite. Locally divided to show small exposure of pyroxene gabbro of unit **KJtp**

KJf **Foots Creek Pluton (Jurassic to Early Cretaceous)-**hornblende diorite. Locally divided to show hornblende gabbro of unit **KJfh**

KJgc **Grays Creek Pluton (Jurassic to Early Cretaceous)-**hornblende biotite granodiorite.

Jj **Jacksonville Pluton (Late Jurassic; 154 Ma)-**hornblende-biotite granodiorite

Jgi **Granodiorite of Grayback and related intrusions (Middle Jurassic; 160 Ma) -**felsic igneous intrusive bodies of all sizes. Typically hornblende-biotite granodiorite but also including trondjemite, quartz diorite, and hornblende diorite. Includes the northern part of the Grayback pluton (160 Ma)**.**

Jgd **Diorite (Middle Jurassic; 160 Ma)-** hornblende-diorite phase of the Grayback pluton.

KTl **Louse Creek Pluton (Triassic to Early Cretaceous)-**Biotite granodiorite associated with the upper part of the Sexton Mountain Ophiolite.

KTj **Jumpoff Joe Creek Pluton (Triassic to Early Cretaceous)-**Biotite granodiorite associated with the upper part of the Sexton Mountain Ophiolite

Other Rocks

sp **Serpentinite (Jurassic)-**serpentinite occurs as sheared lenses or septa along faults and, locally, as matrix for bands of angular to rounded mafic igneous blocks (basalt, diabase, gabbro, peridotite, or amphibolite). Serpentine movement along faults post-dates the sedimentary and volcanic rocks that overlie the ophiolite. The peridotite from which the serpentinite was derived may have been similar in age to the rest of the ophiolite but there is no data other than their proximity. Serpentinite carrying a large percentage of mafic blocks locally occurs in bands that more or less parallel the bedding in enclosing sedimentary rocks and lava flows. Over distances of several hundred meters or more the composition of the blocks in the bands may be more or less uniform. Although faulting is the preferred explanation for these assemblages, an alternative explanation is that they originated as some kind of olistostrome with its source in the nearby Sexton Mountain Ophiolite of Smith and others (1982) or possibly from serpentinite diapirs. In the Murphy quadrangle the lower of two serpentinite bands contains angular to well-rounded blocks derived from one or two of the following lithologies: peridotite (clinopyroxenite? Or harzburgite), gabbro, amphibolite, gabbro-diabase-basalt, diabase, or basalt. These blocks range from a few centimeters to perhaps a hundred meters in extent, averaging about four meters. Gabbro that crops out west of Wimer weathers to blocks of similar size and shape. Bands like these are recognized from Munger Butte in the south to Jumpoff Joe Creek in the north.

cm **Contact metamorphic rocks (Jurassic to Early Cretaceous)-**hornfels and amphibolite in contact metamorphic aureoles developed in wall rocks along the intrusive contacts of plutons. Mapped only where of significant areal extent.

INTRODUCTION

Preliminary geologic maps of the Sexton Mountain, Murphy, Applegate, and Mount Isabelle quadrangles depict the geology of two nearby areas. Both are generally mountainous with valleys that shelter small ranches, farms, and low-density rural residential development. The U.S. Bureau of Land Management and private timberland owners manage forestlands in adjacent uplands. Bedrock geology is dominated by Jurassic and Triassic igneous and metamorphic rocks that have been intruded by Cretaceous and Late Jurassic plutons and overlapped by Cretaceous sedimentary rocks. Valleys locally contain significant Quaternary river deposits, alluvial fans, and terrace remnants.

The Sexton Mountain quadrangle lies generally east of U.S. Interstate Highway 5 north of Grants Pass. It includes large sections of the drainages of Louse, Grave and Jumpoff Joe Creeks. Most of the quadrangle is underlain by the Sexton Mountain Ophiolite of Smith and others (1982). Sexton Mountain itself lies within a wide band of serpentinite-matrix melange that is structurally beneath the ophiolite. The Early Cretaceous Grants Pass pluton underlies the southwestern part of the quadrangle.

The Murphy, Applegate, and Mount Isabelle quadrangles cover 165 square miles, most of which lies south of the Rogue River and north of the Applegate River between the cities of Grants Pass on the west and Jacksonville on the east. Bedrock beneath these quadrangles is interpreted as Jurassic or older meta-sedimentary and meta-volcanic sequences. The upper part of the Sexton Mountain Ophiolite of Smith and others (1982) crops out in the northwestern corner of the Murphy quadrangle. The Grants Pass, Grayback, Timber Mountain, and Jacksonville plutons intrude the older ophiolite and sedimentary sequences. Cretaceous sedimentary rocks assigned to the Hornbrook Formation unconformably overlie meta-sedimentary and meta-volcanic rocks in the eastern part of the Mount Isabelle quadrangle.

Earlier geologic maps include those of Wells (1940) and Smith and others (1982). In his earlier work on the geology of the Klamath Mountains, Irwin (1966) broke out four fault-bounded stratigraphically similar belts of rock (now known as tectonostratigraphic terranes) and assigned rocks in this area to a Western Triassic and Paleozoic belt and a Western Jurassic belt. Most recently, rocks in this general area have been interpreted as northern equivalents of the Rattlesnake Creek terrane of Northern California (Donato and others, 1996, Irwin 2003, Murray, 2002, 2003).

Contacts along small bodies of serpentinite have been uniformly mapped as faults. Other faults have been mapped where observed in the field or where abrupt changes in geology or terrain suggest a fault must be present. Faults are undoubtedly much more numerous than shown, but are difficult to distinguish from small dislocations that accompanied development of regional metamorphic and intrusive fabrics.

GEOLOGIC HISTORY

Broad domes and folds of middle to late Miocene age (circa 9-12 Ma) are reported from areas farther east (Mortimer and Coleman, 1984; Wiley, 199?) and may be responsible for some of the local variation in dip and in metamorphic grade observed in the study area.

Cretaceous and Tertiary sedimentary rocks lie above an angular unconformity (the latter crop out a few kilometers north and east of the study area). Along the western side of the Bear Creek Valley near Jacksonville this unconformity forms an eastward-tilted paleosurface with thin remnants of Late Cretaceous sandstone of the Hornbrook Formation (late Albian-Turonian age; Sliter and others, 1984) lying atop Jurassic metamorphic rock. Somewhat older Cretaceous sequences crop out north of the mapped area near Grave Creek (Albian-Cenomanian) and to the west near O'Brien (Hauterivian-Barremian; Sliter and others, 1984). Rocks at O'Brien have mafic volcanic provenance that contrasts to micaceous-quartzo-feldspathic / rhyolitic provenance seen in both the Jacksonville and Grave Creek areas. Sliter and others (1984) suggest that eastward younging of Cretaceous rocks above the unconformity might be due to eastward transgression of the shoreline. Alternatively, these rocks may reflect deposition during several high sea level stands.

The geologic history of pre-Cretaceous rocks in this area has been complicated by sea-floor metamorphism, regional metamorphism, contact metamorphism, and shearing. This resulted in rocks with few fossils and limited opportunities for meaningful radiometric dating. Chert, for example, has generally been recrystallized such that well-preserved radiolaria are uncommon. Where present, macrofossils and conodonts generally give somewhat older ages than radiolaria (Wardlaw and others, ?; Irwin and Blome, 2004). In their recent summary Irwin and Blome (2004) reported radiolarian ages in this area as old as Sinemurian (Early Jurassic). Macrofossils as old as Paleozoic and conodonts as old as Late Triassic are reported by other workers (Wardlaw?, Irwin and Galanis?). Interestingly, a few Triassic radiolaria are reported from the Coast Ranges west of Cave Junction, in rocks long referred to as the Western Jurassic belt, but Triassic radiolaria have not been recovered from the area between Grants Pass and Jacksonville-in rocks referred to as the Triassic-Paleozoic belt (Irwin and Blome, 2004; Irwin, 1966). Compounding matters, correlations between absolute ages and fossil ages in this part of the geologic time scale are imprecise, with significant differences between timescales of different workers (see Palfy and others, 2000). Important radiometric dates include circa 160 Ma (U/Pb) dates for post-deformation plutons (Saleeby, ????), 177 Ma (U/Pb) for hornblende-bearing pegmatite in a melange gabbro block (similar to Sexton Mountain ophiolite gabbro; Grady, 2005) and circa 175 Ma (K/Ar) hornblende in dikes intruding volcaniclastic rocks (Donato, 199?) and as detrital grains in volcaniclastic rocks (Donato, 199?).

The metamorphic sequences that crop out east of the Grants Pass have surprisingly uniform protolith assemblages. Although the degree of metamorphism varies from lower greenschist to granulite facies, the protolith consists of volcaniclastic-tuff-volcanic sequences alternating with argillite-quartzite-chert sequences. Serpentinite lenses and layers are more common around the periphery of the metamorphic sequence and are largely interpreted as defining faults. Limestone, marble, or tremolite occur as lenses or beds throughout the area. The combination of similar, albeit poorly constrained, ages and lithologic assemblages suggests a reexamination of the proposed assignment of these rocks to multiple terranes (including the Sexton Moutain Ophiolite, May Creek, Rattlesnake Creek, and Western Hayfork terranes) and formations (May Creek Amphibolite, May Creek schist, and Applegate Group).

Metamorphic mineral assemblages and the degree to which mineral segregation banding has developed vary according to the chemistry of the protolith. Metamorphic grade generally ranges from greenschist to amphibolite facies. Rocks that crop out near the Grayback and Birdseye Creek plutons are of higher grade and mapped as unit **cm**.

STRUCTURAL GEOLOGY

Rocks in this area have been assigned to various tectonostratigraphic terranes by previous authors including Irwin (1966; 1972), Blake and others (198?), Donato and others (199?), Donato (199?), Smith and others (1982), and Murray (2002; 2004). Three fault-bounded lithostratigraphic assemblages are recognized in this study. These include 1.) marine shale exposed in the northwest corner of the Sexton Mountain quadrangle, 2.) the Sexton Mountain Ophiolite including both the underlying Greenback melange and the overlying sedimentary and volcanic rocks, and 3.) broken formation that crops out from the Murphy quadrangle eastward to the Mount Isabelle quadrangle. Irwin (200?) places the ??? fault very near the boundary between packages 1 and 2 and he places the Salt Creek fault very near the boundary between packages 2 and 3. In many places the fault between ophiolite and broken formation corresponds to a layer of serpentinite carrying mafic or ultramafic blocks similar to those found in the ophiolite. The upper and lower parts of the broken formation unit have been mapped as the Rattlesnake Creek and Western Hayfork terranes, respectively, by many authors. However, it is difficult to define a distinct terrane boundary north of the Grayback pluton. It may be that the Rattlesnake Creek terrane is cut out along the Salt Creek fault.

Sedimentary units overlie several different types of crystaline bedrock in the Sexton Mountain Ophiolite. This suggests that early seafloor faulting modified the ophiolite before deposition of the first sedimentary rocks. Several repetitions of the ophiolite sequence are apparent in the Sexton Mountain quadrangle. This suggests a later episode of structural thickening along faults that lie between fine-grained units (JTdm, JTb, JTc) to the west and coarser units (JTg, JTdc) to the east. In many places these fault contacts are defined by discontinuous septa of serpentinite that are too small to show on the map. Although the age of this faulting is unknown, it may have accompanied closure of the ocean basin.

Important contacts between the May Creek Schist and the Applegate Group, between the May Creek Schist and the May Creek amphibolite (faulted but interlayered near fault), and between Applegate Group volcanic rocks and quartzite w/ biotite show gradations and interlayering of rocks from either side. The contact between rocks associated with the Rattlesnake Creek terrane and rocks associated with the Hayfork terrane is commonly faulted (Donato, Tallowbox Mtn.) , but may be conformable in the Anderson Butte area where quartz-biotite schist and quartzite are interlayered with meta-volcanic beds

Stitching plutons include the 160 Ma Thompson Ridge, Grayback, Wimer, and White Rock plutons (Saleeby, ????). The Grayback pluton intrudes rocks that Donato et al (19??) correlated to the Western Hayfork and Rattlesnake Creek terranes, indicating that those two terranes were juxtaposed by 160 Ma.

Cooling of plutons is indicated by progressively younger zircon, hornblende, biotite ages for a given intrusive. Radiometric ages reported for the Grants Pass Pluton, for example, range from 139 Ma (U-Pb on zircon; Saleeby, 19??) to 136 Ma (K/Ar on biotite; Hotz, 1971). The Grants Pass pluton intrudes the Greenback Melange, Sexton Mountain Ophiolite, Rattlesnake Creek terrane, and shale units to the west at 139 Ma.

Ramp (1979) depicts a large block of serpentinite (dunite) that crops out along the eastern edge of the 139 Ma Grants Pass pluton in the Sexton Mountain quadrangle as thrust over the pluton. Smith and others (1982) depict the same contact as intrusive. Limited fieldwork along this contact reveals a brecciated zone at the base of the dunite but no obvious zone of contact metamorphism. No dikes of intrusive rock were observed to cut the contact. No clasts of granitic rock were observed entrained in the breccia. The igneous fabric present in the granitic rocks does not appear to parallel the contact as it does where the contact is definitely intrusive. The contact is interpreted as a fault. Similar significant post-139 Ma deformation has been observed to the north at Myrtle Creek where a thick section of Riddle Formation (Late Jurassic to Early Cretaceous [Tithonian-Berriasian] sedimentary rock) is overturned. The O'Brien beds (Hornbrook Formation? Early Cretaceous [Hauterivian-Barremian] of Sliter and others (1984) that crop out south of Cave Junction are locally overturned along faults.

If deposition of the Early Cretaceous O'Brien beds represents an early, transgressive phase of the Hornbrook Formation (Barremian, circa 132-127 Ma; DNAG, 1999; as suggested by Sliter and others, 1984) it implies that unroofing of the Grants Pass Pluton and surrounding rocks occurred in just 4 to 12 million years. Conodont color alteration index of conodonts recovered from nearby limestone and marble beds suggests maximum depth of burial of ???-???. Assuming that most of this unroofing takes place after intrusion and cooling of the Grants Pass pluton gives erosion rates of ??? -??? km/Ma.

High angle faults post-date several of the plutons and the older faults. In the Mt. Isabelle quadrangle, the Hornbrook Formation post-dates early episodes of high-angle faulting but is eventually dismembered by later down-to-the-west faults. This is indicated by the paleotopography of the pre-Hornbrook surface and by preservation of locally derived, coarse grained, angular clasts along faults buried by the Hornbrook Formation. Older occurrences of Hornbrook-like rocks at O'Brien and Grave Creek have similarly been deformed by both broad regional folds and by tight folding and offset along faults.

Following the Applegate River valley westward, remnants of fluvial terraces lie at higher and higher elevations relative to the modern stream. Moring (19??) shows similar terrace profiles along the Rogue River to the north. In some places bedrock lies more than two hundred feet beneath the Applegate River's bed. The best estimates for downcutting by rivers in this area are based on the formation of inverted topography in the Rogue River Valley at the Table Rocks near Medford. There a 7-9 Ma trachyandesite flow lies 200 m (700 feet) above bedrock beneath the Rogue River. This suggest downcutting of about 30m (100 feet) every million years. Faster rates are probably likely farther downstream where the river terrace profiles rise westward relative to the modern stream.

SOILS AND VEGETATION

Soils derived from different geologic units support varied types and amounts of natural vegetation. Existing soil maps depict the major soil units, describe their characteristics, and discuss variations due to downslope movement, elevation, and aspect. The most widespread upland soil units depicted on the soil maps are derived from "altered sedimentary and extrusive igneous rock" with soil "components. . . so intricately intermingled that it was not practical to map them separately at the scale used" (Soil Conservation Service, 1983). The geologic map shows why many of these soil units are complex. In particular, the improved depiction of serpentinite, metasediment, intrusive rocks, alluvium, and volcanic and volcaniclastic rocks gives a somewhat better sense of the distribution of their respective soils. Bedrock contacts that trend roughly north-northeast and, with consideration for downslope movement of landslides and colluvium, the parent material for the different soils will vary along similar trends. The orientation of upper and lower unit contacts and the bedding and foliation symbols shown on the map are typically parallel to the orientation of boundaries between more subtle lithologic changes-and their respective soils-within the map polygons. This should hold true even within the large areas mapped as volcaniclastic rocks on the geologic map.

Some lithologies can be predictably associated with low fuel loads. For a given stand age since the last harvest or fire, low fuel loads are usually recognized on serpentinite, particularly highly sheared serpentinite. The same is true for chert, argillite, and quartzite on which soil development is rather slow. Even where aerial photographs show consistent canopy density, fuel loads in the understory may vary significantly depending on the underlying lithology and soil. Some species best their competition on certain soils. Incense cedar, for example, appears to be more abundant on serpentine soils in this area while widely spaced ponderosa pine are the only trees found in significant numbers on the large dunite body on the west side of Walker Mountain in the Sexton Mountain quadrangle. Secondary mineralization such as sulfide and silica mineralization may limit soil formation and are clearly associated with some of the large rocky, grassy or brushy areas on south-facing slopes.

GROUND WATER GEOLOGY

There are three main aquifer types in this area: shallow alluvial aquifers, aquifers in the weathered zones of large intrusions, and fractured-bedrock aquifers. Shallow alluvial aquifers occur in sand and gravel deposited in fan-shaped wedges at valley mouths and along streams. Along major streams the alluvial aquifer may be more than 30 meters thick, but depth to bedrock rarely exceeds 100 meters. Some of the best aquifers in the area are hosted in the weathered zones of large quartz-diorite, granodiorite, and diorite intrusions. Hills that are underlain by harder or more resistant intrusives, harder zones within intrusives, or contact zones along the periphery of intrusives are less likely to have deep, well-developed weathered zones and are usually better treated as fractured-bedrock aquifers. Along streams with granitic provenance it may be difficult to differentiate between alluvium derived from a granitic source and actual granitic bedrock. Criteria used to determine whether granitic alluvium or granitic bedrock is present include color, drilling rate, and the presence of well-sorted layers comprising repeated fining-upward sequences, clay layers, well-rounded pebbles, wood, or heaving sands (liquifaction). In outcrop most weathered intrusive rocks can be distinguished from granitic alluvium by the nature of crystal-crystal (grain-grain) contacts although rock fragments (pebbles) in the alluvium obviously retain intrusive textures. Areas underlain by shallow metamorphic bedrock are generally characterized by highly variable degrees of fracture porosity. Occassionally large fractures are encountered that deliver large volumes of good quality water. More commonly, wells drilled into metamorphic rock produce small flows of ground water. In general, ground water quality is more variable in fractured bedrock systems than it is in shallow alluvial or weathered-intrusive aquifers. Wiley and others (2005) showed a relationship between the distribution of shallow saline ground water and permeability contrasts in bedrock. They found that in the Grants Pass, Merlin, and Wilderville quadrangles, most natural occurrences of shallow saline ground water are located upstream from dikes, intrusive contacts, bedrock highs in alluvium, steeply dipping unconformities, or faults.

ANALYTICAL PROCEDURE

Dr. Stanley A. Mertzman (Department of Geosciences, Franklin and Marshall College, Lancaster, PA) provided XRF analyses for samples listed in Table 1. Analyses were completed using the following procedures:

The original rock/mineral powder is crushed, using aluminum oxide milling media, until the entire sample passes through a clean 80 mesh sieve. Then, 3.6 g of lithium tetraborate and 0.4 g of rock powder are mixed in a Spex Mixer Mill. The powder is transferred to a 95% Pt-5% Au crucible and 3 drops of a 2% solution of LiI are added. The mixture is then covered with a 95% Pt-5% Au lid (which will also act as a mold), and heated for 10 minutes. After being stirred and thoroughly convected, the molten contents of the red-hot crucible are poured into the lid to cool. A Philips 2404 X-ray fluorescence vacuum spectrometer equipped with a 102 position sample changer and a 4 KW Rh X-ray tube is used for automated data acquisition and reduction. The major elements are determined via this technique together with Cr and V.

Working curves for each element of interest are determined by analyzing geochemical rock standards, data which have been synthesized in Abbey (1983) and Govindaraju (1994). Between 30 and 50 data points are gathered for each working curve; various elemental interferences are also taken into account, e.g., SrK_{β} on

Zr, RbKß on Y, etc. The Rh Compton peak is utilized for a mass absorption correction. Slope and intercept values, together with correction factors for the various wavelength interferences, are calculated and then stored on a computer.

The X-ray procedure determines the total Fe content as Fe_2O_3T. The amount of ferrous Fe is titrated using a modified Reichen and Fahev (1962) method, and loss on ignition is determined by heating an exact aliquot of the sample at 950°C for one hour.

Trace element analysis is accomplished by weighing out 7 g of whole rock powder and adding 1 g of high purity microcrystalline cellulose, mixing for 10 minutes, and pressing the sample into a briquette. Copolywax powder is substituted for cellulose when the whole rock SiO_2 content is >55 weight percent. Data are reported as parts per million (ppm). The elements measured this way include: Rb, Sr, Y, Zr, Nb, Ni, Ga, Cu, Zn, U, Th, Co, Pb, Sc, Cr and V. La, Ce, and Ba amounts have been calibrated using an L X-ray line and a mass absorption correction.

ACKNOWLEDGMENTS

This manuscript is submitted for publication with the understanding that the United States Government is authorized to reproduce and distribute reprints for governmental use.

This geologic map was funded in part 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.

Bob Murray provided helpful suggestions in the field.

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