GEOLOGIC MAP OF THE BEULAH AREA, OREGON

Compilation of geologic maps by
Bowen and others, 1963; Greene and others, 1972; Haddock, 1967;
Lowry, 1968; and Wood 1975

Description of map units

Qal — Alluvium - Alluvial deposits are restricted to the flood plains of the major streams draining the area and two oval shaped depressions; one northeast of the town of Drewsey along Otis Creek in the southwest corner of the map and the other near the Hunter Ranch (SW¼ T.17S., R.38E.). This alluvium consists predominantly of cobble and gravel size detritus near stream banks with a heavy mantling of clays and silts deposited along the flood plain.

Qls — Landslide Deposits - Oversteepened slopes along the Malheur River have caused several areas of slumping and landslides. The most prominent are on the west side of Castle Rock, and another 1 mile east of Agency Valley Dam. At Castle Rock a large rotational landslide block with an area of about 1 square mile, has used the upper pillow palagonite breccia of the "Unnamed igneous complex" as a plane for movement. The hood of the landslide has an arcuate scarp above a flat bench which dips back into the hill side. The toe of the slide is marked by hummocky terrain with many springs and undrained depressions. (Wood, 1975). The landslide east of the Agency Valley Dam is somewhat larger than the Castle Rock slide and has used sediments of the Juntura Formation as a slide plane. The slide area is marked by a characteristic hummocky surface with undrained depressions.

Qtg — Terrace Gravels - Terrace gravel deposits occur in the Castle Rock area and in the Malheur River gorge. In general the terrace gravels consist of well rounded pebbles and boulders up to 6 inches in diameter. The gravels are commonly composed of massive and scoriaceous basalt. About 5 percent of the gravels are made up of metamorphic, granitic and rhyolitic pebbles, which probably originated to the north. (Gray, 1956). Along the Malheur River gorge the gravels occur at elevations of up to 1200 feet above the present elevation of the Malheur River. The position of the gravel deposits indicates that the Beulah and Juntura Basins were once filled with sediments of the Juntura Formation up to about 1200 feet above the present valley floors of the Malheur River.

Terrace gravels mapped 2 miles west and southwest of Castle Rock and 1 to 4 miles north of the Hunter Ranch (SW¼ T.17S., R.38E.) generally consist of a very thin veneer of rounded to angular rock fragments. In part terrace gravels and part colluvium on a pediment surface.

Tri <u>Rhyolite Intrusives</u> - Exposures of rhyolitic intrusives comprise Drewsey Butte (Secs. 26-27 and 34-35, T.20S., R.35E.) and several other buttes in the extreme southwest corner of the map area. Black Butte, about 6 miles southeast of Drewsey Butte out of the map area is similar to the intrusives in the mapped area and is composed of bluish-gray to light-gray rhyolite porphyry with clear euhedral phenocrysts up to 2 mm in length. Flow layering is prominent in some areas but lacking in others. Phenocrysts consist of about 10 percent euhedral sanidine crystals and 3 percent subhedral to anhedral quartz. Magnetite and apatite occur as euhedral accessory minerals (Gray, 1956).

Black Butte is elongated in a north-south direction and probably was erupted along a fissure. The intrusives near Drewsey Butte may be related along a curving north-northwest fissure.

Tdb <u>Drinkwater Basalt</u> - Nearly horizontal flows of olivine basalt which caps the Drewsey and Juntura Formations in the vicinity of Drinkwater Pass. The basalt is dark-gray when fresh and weathers to a dark gray-brown. When numerous large crystals of feldspar occur the rock appears somewhat lighter. In hand samples from the type section at Drinkwater Pass, numerous plagioclase laths up to 2 mm are visible, as are grains of olivine, rimmed with iddingsite. In thin section the basalt has an intergranular texture with pyroxene, olivine, and glass filling the spaces between aligned crystals of labradorite. Modal composition is; Labradorite 50 percent, pigeonite 22 percent, ilmenite 10 percent, olivine 5 percent and the remainder is glass (Shotwell, 1963).

The basalts are thickest in the southern part of the Juntura Basin and thin to the north. Just north of Drinkwater Pass the basalt is 60 feet thick and further north at Juniper Hill (Sec.10, T.20S., R.36E.) a 15 foot thick remnant of basalt caps diatomite of the Juntura Formation.

Intrusive (?) basalt in the diatomite of the Juntura Formation is exposed north and east of Juniper Hill and form small hills 10 to 25 feet high. The surrounding diatomite has been altered to porcelanite and its possible that these are feeder dikes for the capping basalt flows.

The Drinkwater Basalt was deposited on an erosional surface of the Juntura and Drewsey Formations and appears to be a single flow. The basalt has been displaced by northwesterly trending faults and removed by erosion.

Basalts which may represent the western margin of the Drinkwater Basalt occur along the east flank of Stinkingwater Mountain to the west of the map area. Based on the basalts stratigraphic position above the Drewsey Formation and Flora in beds overlying the basalt near Stinkingwater Mountain the Drinkwater Basalt is a late Middle to Late Pliocene in age (Shotwell, 1963).

Td Drewsey Formation - The Drewsey Formation is composed primarily of gray and brown agglomerate, thin beds of diatomite and a basal unit of welded tuff, which is a portion of the Devine Canyon Welded Tuff described by Greene (1973). The type section as described by Bowen, Gray, and Gregory (1963) is along Mule Creek north of the town of Drewsey.

In the Castle Rock area only a few square miles of the Drewsey Formation are exposed, however, it has a more extensive areal distribution in the south west corner of the map area near the town of Drewsey. Here the major depositional basin for the Drewsey sediments is believed to have been located (Gray, 1956) west of what is now Drinkwater Pass (Sec. 34, T.20S., R.36E.).

The basal welded tuff unit is the only portion of the Drewsey Formation well exposed near Castle Rock. In the Castle Rock area there is no definite erosional break between the Drewsey Formation and the underlying Juntura Formation, although near Drewsey the contact is unconformable with the Juntura Formation (Gray, 1956). The basal tuff member is resistant to erosion and often forms steep ledges, commonly protruding from the surrounding incompetent sediments. The tuff is light to medium olive-gray in color, is compact, and has a densely welded central zone surrounded by a thin envelope of lightly welded ash. It commonly shows flattened glass shards and pumice fragments and has a prominent platy jointing. Composition of the tuff is 80 to 90 percent glass shards, 8 to 12 percent flattened lithic and pumice fragments and minor amounts of magnetite and augite.

The welded unit averages about 40 feet in thickness but is often less than 20 feet. The sedimentary strata averages about 160 feet in thickness near Castle Rock but thickens to the west to well over 550 feet (Gray, 1956). Strata above the tuff is generally heavily mantled by talus and vegetation. This sedimentary strata is very similar to the strata of the Juntura Formation exposed below the welded tuff. The sediments are predominatly light-brown clayey tuffaceous sediments occasionally containing abundant angular pumice fragments, and weather rapidly forming poor outcrops.

The welded tuff of the Drewsey Formation has been radiometrically dated at 9.2 ± 0.6 million years in age (Green, 1973). Fossils in the Drewsey Formation indicate that it may be correlative with the Rattlesnake Formation of the John Day Basin to the northwest (Bowen and others, 1963), and it may be equivalent to the lower crystal rich welded tuff of the Danforth Formation (Devine Canyon Welded Tuff in the Harney Basin area).

Tdt Tuff similar to Drewsey - A number of welded ash-flow tuffs in the Beulah area could easily be mistaken for the Drewsey welded tuff unit. They occur as isolated masses in small depressions and generally occur at elevations between 4200 and 5000 feet. One such tuff caps a hill about one mile east of Juntura, it has a composition of 94 percent devitrified glass shards, 4 percent sanidine and 2 percent lithic fragments. Haddock (1967) used the lack of quartz phenocrysts to distinguish the tuff from the Drewsey, although Green (1973) describes the Drewsey tuff as having from 0 to 7 percent quartz.

Another welded tuff similar to the Drewsey tuff is located in the upper Bendire Creek area (N.½, T.18S., R.38E.) in which Lowry (1968) describes a section that may be over 200 feet thick locally and have a source in the vicinity of Baker City Springs, near the old Central Oregon Highway (center, T.17S., R.38E.). This dark-gray tuff contains abundant crystals of potash feldspar and near the source has large pieces of flattened pumice over 30 cm in length. Here the phenocrysts of potassium feldspar and the perlitic groundmass serve to distinguish it from the nearby Drewsey tuff which in this area has few if any phenocrysts of potassium feldspar.

Tj Juntura Formation - A thick section of terrestrial sediments and interbedded volcanic rocks extending up to 20 miles north and west of Juntura. The type locality is located in the Juntura Basin and is split into three parts; an upper section at a quarry about 3 miles south of Petes Mountain; a middle member at Juniper Hill, and a lower section north of Scab Mountain (McClellan Mountain). In the type locality the Juntura Formation is dominantly sedimentary with one basalt flow and several ash beds. In the area south and southwest of Castle Rock it consists of volcanic sandstones, tuffaceous claybeds with water laid tuffs and minor diatomite and interbedded ash. At least two and as many as six thin palagonite basalt flows are interbedded throughout the area. The strata are generally light in color, poorly consolidated but well stratified, showing many sedimentary structures. The oldest strata near Castle Rock is a light-brown to yellow claystone, manganese dioxide staining on bedded planes gives the rock a dark-brown to black appearance. These clay beds may be over 350 feet thick and weather to large rounded hills with a characteristic covering of loose clayey "popcorn" soil.

Above the claystone is a thin but widely distributed volcanic sandstone bed. The sandstone is about 15 feet thick and generally fine-grained, light greenish-gray in color and well sorted with well developed crossbedding. Locally, joints parallel some bedding plains and solutions occasionally form cavities in the rock. Above the sandstone is about 65 feet of more indurated or well compacted light-brown to greenish, tuffaceous, clayey sediments with well developed very fine bedding.

From two to five olivine basalt flows totalling over 130 feet in thickness where all are present, are exposed above the lacustrine strata. A light colored claystone interbed which thickens towards the south separates the lower two flows. Near Horse Flat (Secs. 8 & 17, T.18S., R.37E.) these basalts have a flow-on-flow relationship. The basalts are fine to medium-grained, dark-gray to black with olivine phenocrysts. The rock consists of about 60 percent plagioclase, 10 percent olivine, 5 percent magnetite, 15 percent brownish opaque alteration products and minor amounts of altered augite.

The northern exposures of the Juntura Formation along Jerry Canyon 1 to 2 miles east of Castle Rock are more volcanic in nature than those to the south. This is apparently near the northern edge of the depositional basin which deepened to the south (Wood, 1975). In Jerry Canyon strata composed predominantly of pumiceous air-fall tuffs and minor conglomerates are dominant. These strata are generally light shades of green, brown, gray or white. Two small welded units also occur in the Jerry Canyon area. A light greenish-gray, coarse textured, incipiently welded pumiceous ash fragments which comprise about 10 percent of the rock. The ash also has very small transparent crystals that are barely visible in hand specimen. Immediately above the ash is a light-green to yellowish-gray incipiently welded lithic pumiceous-lapilli-tuff also about 12 feet thick. Nearly identical to the ash except for the larger, 2 to 5 mm, and more abundant pumice fragments which comprise about 50 percent of the rock. The contact between the ash and the tuff is very sharp and conformable and most likely part of the same volcanic episode.

Fossil leaves found near Beulah in the Juntura Formation near Beulah were given an age of upper Miocene (Russel, 1903). The lower portion of the formation is believed to be Late Miocene, and the upper part has been dated from fossils as Early Pliocene (Shotwell and Russel, 1963). Bowen and others (1963) state that fossil mammals from the Poison Creek Formation of Idaho, Deer Butte Formation in eastern Oregon, The Dalles Formation in north central Oregon, and the Truckee Formation in Nevada, indicate that these are all correlative with the upper member of the Juntura Formation. The Bully Creek Formation and the Tims Peak sedimentary and volcanic unit as defined by Haddock (1967), correlates with the upper and lower members of the Juntura Formation respectively. Floras and faunas from the Mascall Formation, Suker Creek Formation, Skull Springs, and Beatty

Butte suggest that they are roughly correlative with the lower member of the Juntura Formation (Chaney, 1959; Downs, 1956).

Tbc Bully Creek Formation - Composed mainly of lacustrine sediments including diatomite, vitric volcanic sandstone, and some conglomerate. The formation occurs along the eastern margin of the map area and unconformably overlies the Hunter Creek Basalt and Littlefield Rhyolite. The type locality is east of the area in the Harper Basin (Kittleman and others, 1965). Further east the Bully Creek Formation is overlain by the Grassy Mountain Formation but in the map area no younger rocks overlie the formation.

Two miles east of the map area along Cottonwood Creek (SE¼ Sec.34, T.18S., R.40E.) is a section described by Haddock (1967) over 420 feet thick. The lower portion consists of yellowish-gray pumice conglomerate and dusky yellowish-gray volcanic sandstone and conglomerate, the conglomerate contains fragments of Hunter Creek Basalt. The upper part consists primarily of diatomite interbedded with volcanic sandstone, ash layers of pure glass shards, and pumice lapilli tuff.

Ttp Tims Peak Basalt - The Tims Peak Basalt unconformably overlies the Littlefield Rhyolite and the Hunter Creek Basalt.

In the area north of Juntura in the vicinity of Beulah Butte and Lake Ridge the Tims Peak sedimentary and volcaniclastic unit which underlies the basalt is mapped separately while to the north near Bendire Mountain the two units are mapped together due to interfingering of the basalts and sedimentary strata. Near Tims Peak in the Monument Peak District, the basalt is thin and consists of only one or a few flows. Northwest of Juntura the Tims Peak Formation consists of many flows with a combined thickness of over 300 feet, east of Beulah Peak the total thickness probably exceeds 500 feet with the total thickness diminishing to the north and east (Haddock, 1967). Individual flows average 50 to 70 feet.

The basalt is medium to dark-gray and is generally holocrystalline, subophitic to ophitic, and microdiktytoxitic. Some flows are porphyritic and have conspicuous phenocrysts that become light gray on weathered surfaces. Modal composition of the basalt is about 55 percent labradorite, 20 percent subcalcic augite, 10 percent olivine, 5 percent opaque minerals, 5 percent glass, 5 percent void space and traces of apatite and alteration. Differential weathering of the minerals making up the ophitic groundmass causes small mottled spots on the rock.

Feeder dikes to the Tims Peak Basalt are exposed southwest of Beulah Peak (NW¼ Sec.1, T.20S., R.37E.) and along Warm Springs Creek (SE¼ Sec.10, T.19S., R.38E.). Both dikes are small and more probably exist under the basalts.

Kittleman and others (1965) named the Tims Peak Basalt from an exposure near Tims Peak in the Monument Peak district. Hagood (1963) used the name informally and Bowen (1956) and Gray (1956) mapped areas containing it but grouped it with the Owyhee Basalt, which by Bowen, Gray and Gregory (1963) is called the basement complex.

Tuv Tims Peak sedimentary and volcaniclastic unit - An unnamed sedimentary unit consisting of volcaniclastic sandstone and diatomite up to 200 feet in thickness. Where mapped together, the Tims Peak Basalt interfingers with the sediments and exposures are too poor to map separately. The sedimentary unit generally underlies the basalt and in most places is composed of impure diatomite with thin beds of sandstone and pumiceous material. Southwest of Westfall Peak (Sec.5, T.19S., R.39E.) the sediment contains rounded pebbles of obsidian from Westfall Peak. Two palagonitic tuff rings, one north of Jonesboro (Sec.21, T.20S., R.39E.) and the other on the east side of Bendire Ridge (Secs.24-25 T.18S., R.38E.) are exposed in this unit. Basaltic pillows are present at the top of the sediment along Pole Creek and in section 29, T.20S., R.38E.

The underlying sedimentary unit has greater areal extent than the basalt flows, so it is in contact with sediments of the Bully Creek Formation to the northeast and possibly with the Juntura Formation east of Beulah Reservoir. It is therefore possible that the lower unfossiliferous part of the Juntura Formation, as defined by Bowen, Gray and Gregory (1963), correlates at least in part with the sedimentary unit of the Tims Peak Basalt (Haddock, 1967).

Ttpv Tims Peak Volcanics not mapped separately - Basalt flows of the Tims Peak Basalt and impure diatomite, sandstone, and pumiceous material of the Tims Peak sedimentary and volcaniclastic unit that have interfingered too intimately to be mapped as separate units.

Tsvu Strawberry Volcanics undifferentiated - This unit as defined here includes eight other formations and units mapped separately in the central portion of the Beulah map, primarily that area mapped by Wood (1975). The northwestern and west central portions of the map are mapped as the undifferentiated Strawberry Volcanics as described by Thayer and Brown (1966) however, it should be viewed with the understanding that it contains these diverse units and perhaps younger units as well. In this paper each unit will be described separately.

The Strawberry Volcanics are made up of a complex series of silicic to mafic lava flows, tuffs, and sedimentary interbeds, first described by Thayer (1957). Lava flows of the Strawberry Volcanics were included in the "basement complex" of Bowen and others (1963) and the Columbia River Basalt by Lowry (1968).

Tsv Strawberry Volcanics, silicic to basaltic lava flow unit - A series of basalt, andesite, and dacitic lava flows. Basaltic lava flows are characteristically dark-gray to black, very fine-grained with platy jointing and greenish streaks of alteration products between flow laminations. The basalts are hypocrystalline and micro-porphyritic, with badly altered plagioclase and pyroxene phenocrysta about 1 mm in length. Fine plagioclase crystals, crystallites and microlites comprise about 70 percent of the rock and are well aligned and curve around larger crystals. Phenocrysts of plagioclase make up about 1½ percent of the rock, and pyroxene less than ½ percent. A glassy matrix comprises about 20 percent and a dusty magnetite forms almost 5 percent of the basalt. Flows average about 50 feet in thickness, and have very platy jointing parallel to the base of the flow. Several flows have high undulating wave-like viscous flow structures. Another common structure is concentric radial jointing enclosed within a poorly developed vertical jointing similar to those caused by lava solidifying in a lava tube within a flow.

Silicic flows tend to be very fine-grained, medium to dark-gray in color although some are shades of light-brown. Feldspar and pyroxene crystals are commonly visible on fresh surfaces. Dark Flows commonly have a green mineral banding and a fine platy jointing. This jointing is commonly undulating and develops along incipient flow layering. Weathered surfaces of these rocks are often a light-brown color.

Tlc Lost Creek Volcaniclastic Member - The Lost Creek member consists of over 20 lithologically similar pumice-lapilli tuffs, one yellowish-brown volcanic conglomerate and two light-gray to brown ashy beds. The pumiceous tuffs range from 6 to over 150 feet in thickness. The tuffs are dull shades of light-gray to brown. Flattened pumice lapilli 4 to 25 mm are most common, but angular fragments over 15 cm are not unusual. Composition of the pumiceous tuffs is 5 to 10 percent lithic fragments, 30 to 70 percent ashy matrix and pumice comprises most of the remainder. Other constituents include plagioclase, augite and minor hornblende. The Lost Creek tuffs range from non-welded to lightly-welded with angular fragments and a general lack of bedding.

In the vicinity of Castle Rock the Lost Creek tuffs cover about 7 square miles and is believed to underlie several times this area. The minimum regional distribution is about 600 square miles. These strata have a total thickness of over 600 feet but tend to thin away from Black Butte (east center, T.17S., R.36E.). Deposits are typically lens shaped where they have filled several small basins. The distribution and thickness of some of these units suggests a source near Lost Creek (west½, T.17S., R.37E.) (Wood, 1975). Lowry (1968) described a volcano remnant related to these tuffs on the east side of Rail Creek (SW¼ Sec. 14, T.16S., R.38E.) No fossils have been found in the Lost Creek Volcaniclastics to date the unit by, but on the basis of stratigraphic position above the Dinner Creek tuff, it is assigned an age of very Late Miocene to Early Pliocene.

Tb Basalt Plug in Phyolite Intrusion - Within the rhyolite intrusion in the Westfall Butte area is a semicircular basalt plug about 1000 feet in diameter that forms a peak between Westfall Peak and Westfall Butte (SE¼ Sec. 5, T.19S., R.39E.) The chilled margin of the plug contains abundant xenoliths of rhyolite, and the basalt assimilated much of the siliceous material. Flow layering in the margins dips steeply toward the center. The rock toward the center of the plug is much darker than near the margins, and at the center, dark-gray aphanicit basalt, vesicular basalt, and some scoria are present. The development of vesicles and scoria indicates very shallow depth at the time of formation. The age is tentative and based soley on its relationship with the surrounding rhyolite intrusion.

Tri Rhyolite Intrusion and Associated Flows - A rhyolite intrusion about 2 miles in diameter pierces the Dinner Creek Welded Tuff and the Hunter Creek Basalt and material from the intrusion reached the surface and flowed about 3 miles north beyond Westfall Butte. Rocks near the margin of the intrusion are light to medium-gray flow-banded rhyolite, obsidian and autobrecciated gray glass. A dark-gray rhyolite that contains fragments of the light gray rhyolite forms part of the core of the structure. The lower flows in Westfall Butte are of light-gray, flow-banded rhyolite, and the upper flows are a dark-gray rock with inclusions of light-gray rhyolite. Some of the upper flows have the reddish-gray coloration and the platy characteristic of the Littlefield Rhyolite. It is probably that the entire intrusion and associated flows constitute one aspect of the Littlefield Rhyolite (Haddock, 1967).

Strata of the older rocks are upturned on the east flank as steeply as 35 degrees. Obsidian fragments from the intrusion occur in the sedimentary unit of the Tims Peak and a flow of Tims Peak Basalt overlaps the western part of the rhyolite flows. A fault, possibly related to a later phase of intrusive activity, uplifted Westfall Butte and exposed the Dinner Creek beneath the flows. The stratigraphic relationships place the rhyolite intrusion somewhere between the Dinner Creek Welded Tuff and the Tims Peak Basalt, or roughly Middle to Late Miocene.

Tir Littlefield Rhyolite - The fresh rock is dark-gray and abundant phenocrysts in the glassy groundmass give the impression of an aphanitic texture, so the rock superficially resembles a basalt. Weathered rock surfaces become grayish-red, which is a distinctive characteristic of this formation. In some specimens the color forms a thin rind as if it were a weathering feature and in others the color penetrates completely through the rock suggesting that it may be the result of deuteric alteration. Flow banding is usually well developed and gives the rhyolite a platy to flaggy fracture. Except for the steepest slopes the rhyolite is mantled with platy rubble. The platy fracture is the most representative structural characteristic, however, at some exposures, spherulites, highly contorted flow banding, autobreccia and columnar jointing occur. A black massive vitrophyre is also included in this formation, but does not have the grayish-red color associated with weathered rhyolite.

The rock consists primarily of glass, wholly or partly devitrified, in which there are numerous microlites and some phenocrysts, few of which exceed 2 mm in length. Andesine, clinopyroxene, and magnetite are the minerals occuring most commonly as phenocrysts. The silica content may vary from 63.4 percent to over 70 percent (Kittleman, 1965).

East of the map area the black vitrophyre is in juxtaposition with the Hunter Creek Basalt, and the contact is difficult to trace because the regolith above both rock units is very similar. The weathered vitrophyre does not have the grayish-red color of the rhyolite, but is dark-gray like the basalt.

Source vents for the rhyolite are widely distributed explaining its widespread occurance over northern Malheur County and for an undetermined distance north, south and west of the Beulah area.

The Littlefield Rhyolite was named by Kittleman and others (1965) for exposures at the Littlefield homestead (Sec. 35, T.23S., R.40E.). The rhyolite unconformably overlies the Hunter Creek Basalt and the "unnamed igneous complex." To the north the rhyolite is overlain by younger formations such as the Bully Creek Formation, while in other areas some topographic highs capped by the rhyolite show no evidence of ever having been covered by younger formations.

Age of the rhyolitic determined by fossils in the overlying Butte Creek Volcanic Sandstone in the Monument Peak area, was established as no younger than Late Miocene by Kittleman and others (1965) and Evernden and others (1964) gave a potassium-argon date of 15.1 m. y. for high temperature Na-K feldspar from the sandstone.

Thc Hunter Creek Basalt - The Hunter Creek Basalt was named for exposures along Hunter Creek in section 26, T.21 S., R.39E. (Kittleman and others, 1965). It is underlain by the pumice lapilli tuff and pumiceous sandstone unit of the Dinner Creek Welded Tuff and underlies the Littlefield Rhyolite, Tims Peak Basalt, and the Juntura and Bully Creek Formations. The basalt is aphanitic, medium to dark-gray with greenish streaks of alteration products between flow layers. Thin sections of the basalt show the texture to be microcrystalline, felty to pilotaxitic, intergranular to intersertal. The average modal analysis of the basalt is 49 percent labradorite, 30 percent clinopyroxene, 7 percent opaque minerals, and 14 percent glass. Silica content ranges from 48.0 to 54.4 percent (Kittleman, 1963) using the glass-bead method.

Large areas underlain by the Hunter Creek Basalt characteristically have sparse vegetation, broad dip slopes incised by streams and the basalt forms a terrain of low domed hills covered with basalt rubble. Closely spaced joints causes the basalt to break into 2 to 6 inch angular fragments and patterned ground with stone stripes and polygons cover much of the surface underlain by the basalt.

The Hunter Creek Basalt is present with the Dinner Creek tuff southwest of Warm Springs Reservoir in Harney County and crops out near Bully Creek Reservoir north of Vale, the two localities being over 50 miles apart (Haddock, 1967). Wolff (1965) believes that an aphanitic black basalt in the north part of the Caviness quadrangle is probably correlative with the Hunter Creek Basalt.

At the type locality the Hunter Creek Basalt is 150 feet thick (Kittleman and others, 1965), Hagood (1963) reported a thickness of 400 feet in the Monument Peak area, and Haddock (1967) measured a thickness of 140 feet in the Malheur gorge. The only vesicular or scoriaceous zone in the basalt is at the top of the unit where overlain by Tims Peak Basalt. The rest of the unit is dense and no vesicular zones have been observed within the Hunter Creek Basalt.

Horizontal planes across which there is a sharp break in the jointing pattern occur along Cottonwood Creek (Sec. 10, T.19S., R.40E.) east of the map area, but it is uncertain whether these planes represent separate flows or surges of the same flow or simply sheeting planes within one flow. The number and distribution of flow units within the Hunter Creek Basalt has not been determined. It is possible that the entire unit is a single flow.

Tdc Dinner Creek Welded Tuff - The Dinner Creek tuff is a prominent marker bed through out much of the Beulah area. It is composed of three basic units, the lower of which is a nonwelded, unstratified, pumice-lapilli tuff ranging in thickness from 15 to 55 feet and lying unconformably over the unnamed igneous complex. This pumice-lapilli tuff is apparently an air-fall deposit, laid down prior to the welded ash flow unit above it. Lack of reworking or a soil zone suggests a very short interval between the deposition of the air-fall material and the ash-flow deposit, probably both are a part of the same event. The contact between the lower unit and the middle unit is marked by an abrupt change from pumice-lapilli tuff to glass shards. This middle unit is a densely welded rhyolitic ash-flow tuff ranging in thickness from 17 to over 250 feet and commonly forms cliffs with the entire unit exposed. A fresh hand speciment of the welded unit has a dark violet or lavender to dark reddish-gray color and weathers to a distinctive purplish-red. The tuff developes a more reddish appearance with increasing distance from the vent area. Less welded zones may be light-brown, very light-purple or greenish and weather to a red-brown color. Flow layering is very prominent on a small scale, about 1mm intervals, and imparts a very distinctive fracture cleavage which causes the rock to split into plates about 4 mm in thickness. The rock itself consists of 4 to 5 percent pumice fragments, 1 to 4 percent sanidine and potassium feldspar and up to 5 percent xenolithic fragments in a matrix of purplish-gray glass.

The third and upper unit is a non-welded zone of stratified pumice-lapilli tuff and pumiceous sandstone ranging in thickness from 40 to 110 feet. It is probably reworked surface material from the non-welded zone and is commonly buried under talus of the Hunter Creek Basalt.

The type locality for the Dinner Creek Welded Tuff is south of the map area along Dinner Creek southwest of Jonesboro (NW¼, Sec. 30, T.21S., R.39E.).

The extent of the Dinner Creek tuff is not known. The eastern most exposure mapped is near Namorf (Sec. 31, T.20S., R.41E.), and to the south one lobe extends beyond Warm Springs Reservoir in Harney County. Both to the south and west the Dinner Creek dips beneath younger strata. Dinner Creek mapped to the west is about 200 feet thick, and although a structural north-south low probably existed at the time of extrusion (Haddock, 1967) it is still reasonable to expect the tuff to extend further west under younger rocks. To the north, the Dinner Creek tuff is exposed over large areas of the south-eastern part of the Ironside Mountain quadrangle and in the south half of the Caviness quadrangle. Wolff (1965) has tentatively identified a welded tuff in the northern half of the Caviness quadrangle, more than 40 miles from the type locality as Dinner Creek tuff. Haddock (1967) calculated the areal extent of this tuff to be between 1000 and 2000 square miles.

A probable source area for the Dinner Creek tuff is the Castle Rock area. The dikes at Castle Rock and Black Butte are most likely vents for the Dinner Creek Welded Tuff and may represent the southern most extension of north-south trending dikes emplaced in parallel orientation reflecting a regional structural trend (Wood, 1975). Basalt along the lower walls of Castle Rock ridge dip 20 degrees to the northwest and erosional remnants of autobrecciated flows of Dinner Creek Welded Tuff occur on the basaltic slopes with blocks up to 10 feet in diameter. This is the only area where near vent characteristics are found in the Dinner Creek. Flow layering is steeply inclined in the southern end of the Castle Rock dike but dips an average of 37 degrees to the northwest at the opposite end. Flow layering in the northern end dips towards Black Butte suggesting that the two may be connected at depth. A contact at the south end of Castle Rock indicates that the dike occupied a topographic high at the time of extrusion and flows traveled down over basalts of the "unnamed igneous complex" into valleys on both sides of the ridge. These valleys are traceable only by the thick accumulations of Dinner Creek which roughly parallel the present valleys.

The Dinner Creek welded tuff has been referred to as the welded tuff in the Owyhee Basalt by Bowen (1956) and Gray (1956). Later it was referred to as the welded tuff of the Basement Complex (Bowen, Gray and Gregory, 1963), and also as the Dinner Creek Welded Ash-Flow Tuff Member of the Crowley Formation (Hagood, 1963).

Tuic <u>Unnamed Igneous Complex</u> - This unit has never attained formational status and no type section has been designated. The exact stratigraphic relationships on a regional basis is lacking, although it is believed that the unit may be correlated with part of the Steens Mountain Volcanic Series.

The "unnamed igneous complex" has an areal extent of over 750 square miles and south of Castle Rock is over 2000 feet thick. Although the complex has a wide areal extent, individual basalt flows are for the most part of limited extent and in the Castle Rock area average from 30 to 50 feet in thickness and from 4 to 60 square miles in areal extent, (Wood, 1975), which would tend to distinguish them from the extensive Columbia River, Steens or Owyhee flood basalts which the "unnamed igneous complex" might be correlated with.

In the Castle Rock area the "unnamed igneous complex" consists of dense, porphyritic, palagonitic and vesicular basalt flows with two interbedded pillow palagonite breccias (Wood, 1975). This section is similar to one measured in the southeast corner of the map area (SW¼, Sec.34, T.20S., R.38E.) by Haddock (1968), however, the lower portion of the Castle Rock section contains two porphyritic basalt flows and some coarser-grained flows not described by Haddock.

The pillow palagonite breccias in the lower part of the Castle Rock section are composed of fine-grained and glassy basalt fragments with lesser amounts of crystalline basalt fragments. Rims of black glass common to pillow basalts, are often surrounded by palagonitic breccia. Breccias of the two sections are similar and both contain zeolites, calcite and amorphous silica, but Haddock described no pillow structures.

Wood (1975) has divided the basalts of the "unnamed igneous complex" into porphyritic and aphanitic groups. The section at Castle Rock consists of over 25 individual flows of which only four are porphyritic. The porphyritic flows are generally hypocrystalline with an intergranular groundmass texture. Phenocrysts commonly comprise 20 percent of the rock with plagioclase crystals comprising about 75 to 90 percent of the phenocrysts while olivine and pyroxene make up the rest. Plagioclase calcite and amorphous silicic are common in these flows. Groundmass plagioclase (An_{58-63}) comprises about 30 percent of the rock. Glass makes up about 40 percent of the rock and the remaining 5 percent is composed of secondary minerals and alteration products. Magnetite, olivine and pyroxene occur within the angular intersticies between plagioclase laths in the groundmass.

The more common aphanitic basalt flows are usually hypocrystalline, generally have intergranular to intersertal and sometimes subophitic textures with sparse phenocrysts. The aphanitic basalts are generally composed of 40 to 50 percent plagioclase, 20 to 35 percent augite, 0 to 5 percent olivine, 5 to 10 percent opaque minerals and alteration products.

Kittleman and others (1965) tentatively established the age of the "unnamed igneous complex" as no younger than Late Miocene because of Barstovian mammalian fossils in Butte Creek Volcanic Sandstone which indirectly overlies the complex to the northwest. Fossils of the same age overlie the Owyhee Basalts.

The general attitude of the unit is to dip towards the northwest, exposing older flows towards the southeast. Beaulieu (1972) believes that about 1000 feet of intercalated autoclastic breccias and dense aphanitic basalts exposed in the Crowley area (Green, 1962) represent a lower portion of the section. The middle part of the section is probably represented by 650 feet of multiple-flow porphyritic, olivine basalt overlain by about 750 feet of flaty aphanitic andesite and andesitic basalts exposed in the Monument Peak area (Hagood, 1963). The upper part of the section is believed represented by the porphyritic massive aphanitic flows and breccias exposed in the Castle Rock, Malheur Gorge and Central Monument Peak areas comprising a section nearly 2300 feet thick. Correlation between these areas is difficult due to the small areal extent of individual flows which were extruded from numerous central vents and fissures and the lack of any well defined marker beds. Due to interfingering of flows and the lack of marker beds the total thickness of the "unnamed igneous complex" is believed to be a minimum of 2250 feet.

The "unnamed igneous complex" is possibly correlative with the Steens Mountain Volcanic Series, Steens Basalt, Owyhee Basalt and other lava complexes of western Idaho, northern Oregon and southern Washington. They are believed younger than the Columbia River Basalts (Baldwin, 1964), but are similar in age and their exact relationships are uncertain.

In early work on the area the "unnamed igneous complex" was included in a group termed the "Basement Complex" (Bowen, Gray, and Gregory, 1963), which also included the Dinner Creek Welded Tuff, Littlefield Rhyolite, Hunter Creek Basalt, and other units which have since received formational status by Kittleman (1965). However, flows of the "Basement Complex" were also included in the "Strawberry Volcanics" of Brown and Thayer (1966) in the Castle Rock area. Presently, flows of the "unnamed igneous complex" are stratigraphically below the Dinner Creek Welded Tuff.

Trb Ring Butte Andesite - A medium to dark-gray and locally black andesite; reddish varieties are sometimes seen. The andesitic plugs and some of the smaller dikes are nearly as light-gray as the porphyritic Truman Ranch Diorites and may be difficult to distinguish in hand specimen. However, in the large dikes exposed along Clover Creek (T.16S., R.38E.) the andesite is dark-gray. The coarse volcanic breccias also tend to be light-gray due to the ash content. Nearly all the andesites, whether volcanic breccias, dikes, plugs or flows are porphyritic and not uncommonly trachytic.

The type locality is Ring Butte (Sec. 14, T.16S., R.37E.) in the north central portion of the map. A fairly representative description was given by Lowry (1968) for a sample collected north of the map area (Sec.18, T.13S., R.38E.). A medium to dark-gray porphyritic andesite which under the microscope is seen to have a hemicrystalline, trachytic texture with phenocrysts up to 3.5 mm long. Phenocrysts constitute about 40 percent of the section. Subhedral andesine phenocrysts with albite twinning make up about 25 percent of the rock and hornblende about 8 percent. Subhedral phenocrysts of enstatite-hypersthene, augite, and grains with parallel intergrowths of orthopyroxenes and clinopyroxenes each constitute about 1 percent of the section, anhedral crystals of biotite consititue about 1 percent and magnetite about 2 percent. The groundmass has a microlite texture with microlites and laths of feldspar making up to 45 percent of the section. Six percent of the groundmass is orthopyroxene, 5 percent clinopyroxene, and 2 percent magnetite. Brown glass, for the most part devitrified and showing perlitic structure occurs as phenocrysts and also in the groundmass.

The Ring Butte is restricted to the north-central portion of the map area where it rests unconformably on the Pre-Tertiary Rastus Formation. The andesite is stratigraphically above the Rastus Formation of Late Jurassic-Early

Cretaceous age and below the Dooley Rhyolite of probable late Eocene - early Oligocene age. Correlation with adjacent areas indicates an Eocene age (Lowry, 1968).

The Ring Butte Andesite and the "andesitic tuff-breccia" of the Sumpter quadrangle (Pardee and Hewett, 1914) to the north are identical. This unit is also equivalent to the andesitic tuff-breccia near the southwest corner of the Baker quadrangle (Gilluly, 1937) northeast of the Beulah area.

KJd Tureman Ranch Diorite - At the type location for the Tureman Ranch Intrusive (Sec. 10, T.16S., R.37E.) it is a salt and pepper, light to medium gray, equigranular, biotite-hornblende diorite. Other exposures of the diorite are generally biotite-free, hornblende-quartz diorite which is characteristically porphyritic. The quartz content of many of these bodies is too low to justify the term quartz-diorite. Diorite at the type location is very uniform in appearance, while exposures in other areas are often quite porphyritic. Diorite at the Tureman Ranch also differs from equigranular varieties in other areas in being coarser grained; most of the feldspar grains are characterized by move zones; and the grains tend to be strained, some highly; and the rock has directed texture and foliation. At the type location biotite comprises about 14 percent of the rock, and greenish-black hornblende about 6 percent. Most of the rock is composed of plagioclase with a small percentage of quartz, although in other areas quartz may account for up to 15 percent of the rock.

Dating of the Tureman Ranch Diorite has resulted in several different ages. A sample dated by the potassium-argon method gave a date of 120 ± 6 million years (Thayer and Brown, 1964), while a zircon lead-alpha determination for another sample gave a date of 100 ± 15 million years (Thayer, 1965). Another sample collected about 15 miles northwest of the map area gave an age of 145 million years using the potassium-argon method (Thayer and Brown, 1964). Lowry (1968) tentatively refers to the age of the intrusives as Late Jurassic - Early Cretaceous. The varying ages obtained and the lithologic variations within the diorite could also indicate several periods of intrusive activity over a fairly long period of time rather than one large intrusion.

The Tureman Ranch Diorite intrusives are considered to be roughly equivalent in age to similar intrusives in the Blue and Wallowa Mountains and in the Klamath Mountains of southwestern Oregon and northern California (Lowry, 1968).

J₹t Rastus Formation - A thick group of limy tuffs, slaty shales and lavas of Triassic and Jurassic age. In general, dark grayish-green colors and fragmental textures characterize the rocks of the Rastus Formation. They are exposed in a northeast trending belt showing east and northeast structural trends common in Pre-Tertiary rocks of the region.

Chlorite-bearing limy tuffs are the dominant rock type in the Rastus Formation. They generally appear to be thick bedded or massive, but fracture cleaved. The limy tuffs comprise up to 75 percent of the formation. Similarly cleaved shales are abundant in some areas but are less noticeable since the limy tuffs are generally the only rocks that crop out on ridge tops and slopes. Of the other rock types, none make up over 5 percent of the total formation. Limestone is uncommon, but due to its massive structure and few fractures, it crops out prominently. Fine-grained cherty sediments occur occasionally, and quartzose sandstones are rare except near the contact with the oldest rock units further north. Fractured lavas of intermediate composition crop out in several places, but most of the volcanic material in the formation is of pyroclastic origin.

The thickness of the Rastus Formation has been estimated to be up to 17,000 feet (Lowry, 1968). About 12,000 feet of beds are exposed between the crest of the Lost Creek anticlinorium and the trough of the South Willow Creek synclinorium. An additional few thousand feet are present to the northeast down the plunge of the synclinorium near Pine Butte where the youngest beds are believed to be present.

Fossils in Rastus strata range in age from Late Triassic to early Middle Jurassic (Lowry, 1968). The Rastus formation is probably equivalent to the Upper Triassic sediments in the John Day, Mount Vernon, and Aldrich Mountain quadrangles mapped by Thayer (1956). The formation is also most likely correlative with the Triassic and Jurassic rocks mapped by Wallace and Calkins (1956) in the Izee and Logdell quadrangles. Similar rocks have also been described further west in the Suplee area and in the Suplee-Izee area by Dickinson and Vigrass (1965).

per Ultramafic Intrusives - Small bodies of peridotite and serpentinized peridotite which cut the Mine Ridge Schists. As with the schists these rocks do not occur in the map area but to the north they are associated with the schists. The peridotite is little layered except where cut by steeply dipping, east-striking bands of serpentinized peridotite several feet or less in width. Weathering results in a characteristically dark, rusty brown color, but fresh surfaces appear uniform gray to black. Peridotite samples show a holocrystalline porphyritic texture developed from an original equigranular texture altered in part by secondary fiberous masses. Proportions vary considerably among samples but relic olivine crystals comprise one-third or more of the rock and are separated by areas of chrysotite, antigorite, chromite and radiating aggrate of anthophyllite. The ultramafics are confined to narrow dikes or small stocks cutting the Mine Ridge Schist. The ultramafics are most likely at least Paleozoic in age and possibly Precambrian, (Lowry, 1968).

mrs <u>Mine Ridge Schists</u> - The rocks of this formation do not occur in the mapped area but do outcrop about 20 miles north of Castle Rock (T.14S., R.36E. and T.13S., R.38E.). They roughly trend north-northeast and may be remnants of a Pre-Tertiary mountain range. They are mentioned here because they map dip to the south or southeast and underlie the Beulah area at depth.

Mine Ridge Schists are composed of a variety of rocks. Quartz-garnet schist, hornblende and actinolite schists, quartz-mica schists and talc schists are represented. Most of the schists show flowage-folding effects caused by metamorphism with stresses sufficient in many cases to fold the chlorite, amphibole, and mica into minutely crenulated structures. Structures in the schists show no uniform attitude and although the schists are locally cut by shear fractures, they do not show regional fracture cleavage.

The schists originated as sedimentary deposits of quartzzose sands, silts, argillaceous sediments and basic pyroclastics probably deposited in Precambrian time (Lowry, 1968). Burial apparently was to a depth of at least 15,000 feet and metamorphism occured prior to Middle Devonian and possibly Precambrian (Lowry, 1968).

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IRONSIDE MOUNTAIN QUADRANGLE (OREGON)