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GEOLOGY AND MINERAL RESOURCES MAP OF THE ELBOW QUADRANGLE, MALHEUR COUNTY, OREGON

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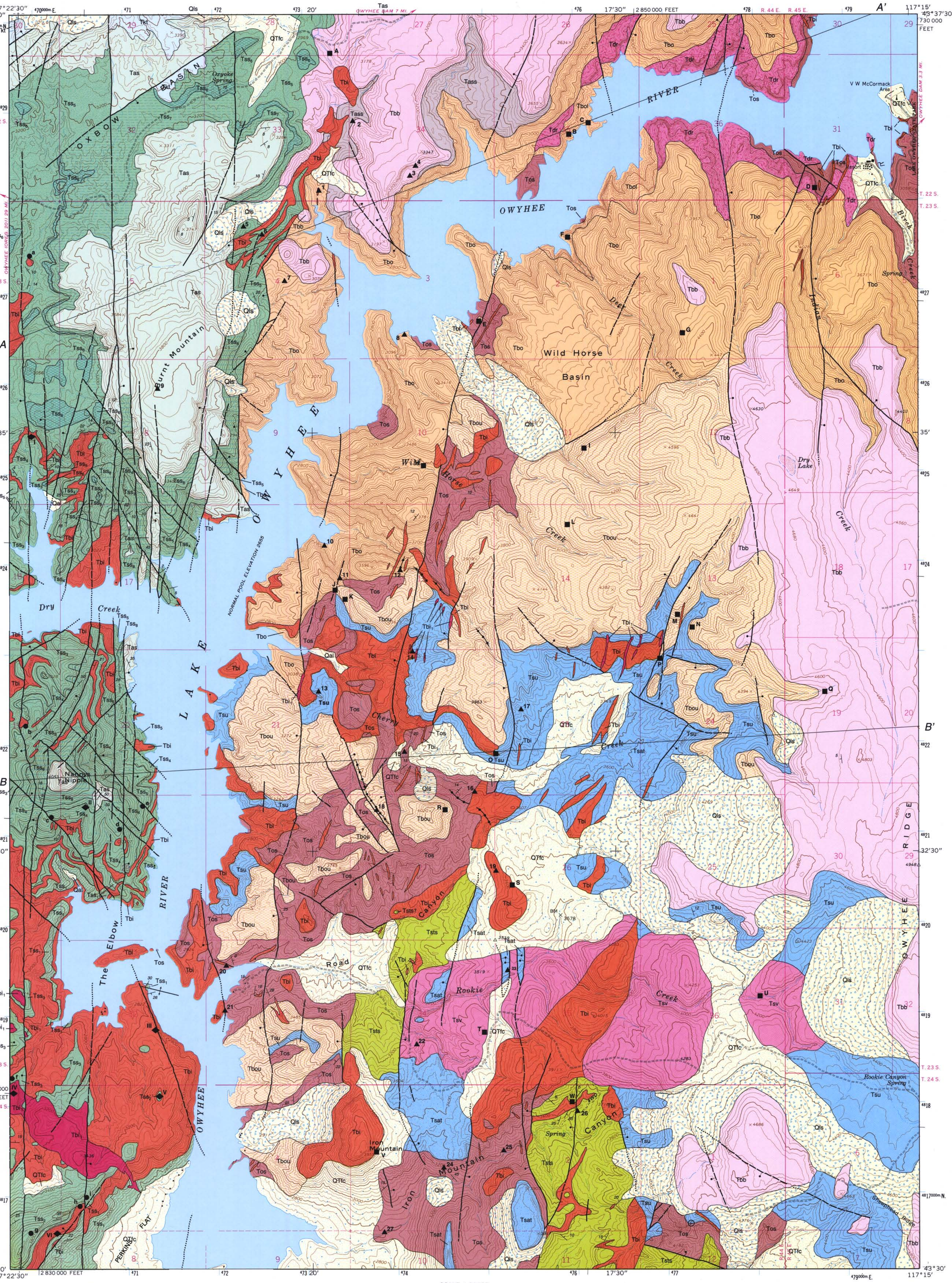
Geology and Mineral Resources Map of The Elbow Quadrangle, Malheur County, Oregon

By M.L. Ferns and M.L. Cummings

Funded jointly by the Oregon Department of Geology and Mineral Industries, the Oregon State Lottery, and the U.S. Geological Survey COGEOMAP Program, with contributions from private mining companies to Portland State University, as part of a cooperative effort to map the west half of the 1° by 2° Boise sheet, eastern Oregon

Plate 1



Base map by U.S. Geological Survey
Control by USGS and NOS/NOAA
Topography by photogrammetric methods from aerial photographs taken 1966. Field checked 1967
Polyconic projection. 1927 North American Datum
10,000-foot grid based on Oregon coordinate system, south zone. 1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue

UTM GRID AND 1967 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

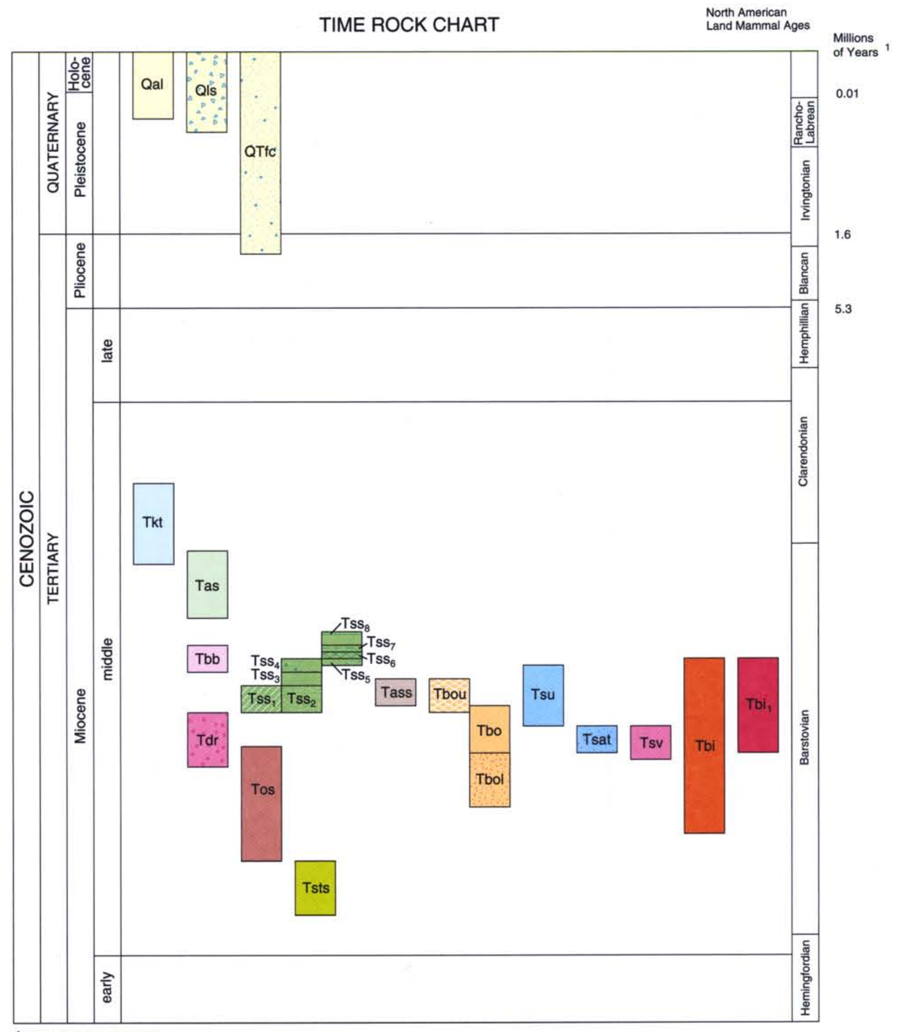
Geology by Mark L. Ferns, Oregon Department of Geology and Mineral Industries, and Michael L. Cummings, Portland State University

Field work conducted in 1988-1989

Reviewed by James G. Evans, U.S. Geological Survey, and William K. Hart, University of Miami, Oxford, Ohio

Cartography by James E. Meacham, David Cutting, and Nancy Leeper, University of Oregon Geography Department

TIME ROCK CHART



1 Dates from Palmer (1983)

MINERAL RESOURCES

Metallic mineral resources

Gold resources may occur in the quadrangle. Anomalous concentrations of gold were detected in samples from both sides of Lake Owyhee. A sample of strongly silicified siltstones of unit Tss_5 northeast of Burnt Mountain (sample 5, Table 1) contained 54 ppb Au. The sediments here are intruded by northeast-trending basalt dikes and sills that parallel one of the faults between units Tss_5 and Tbo. Strongly silicified arkosic sandstones of unit Tas cap Burnt Mountain to the southeast. Unit Tas conglomerate lenses on Burnt Mountain contain small, rounded sinter fragments. Anomalous concentrations of gold occur in the light-colored, siltstone-bearing matrix of a basalt-clast breccia along the footwall of a fault on the west flank of Nannys Nipple. The matrix contains 100 ppb Au (sample OW-433, Table 3) and is interpreted to be the matrix in a diatreme of a basalt hydrovolcanic deposit.

Large, multi-stage calcite vein systems crop out across the reservoir to the southeast. The northernmost vein, known as the old Calcite King prospect and located in sec. 15, T. 23 S., R. 44 E., is more that 5 m in thickness and can be traced for over 700 m along strike. A sample of calcite breccia from a much smaller, north-striking vein near here yielded 22 ppb Au (sample 12, Table 1). Two large, northwest-trending vein systems that crop out to the south in the N½ sec. 27, T. 23 S., R. 44 E., were located in the past as the Calcite Miner and Sheep Horn claims (Lowry, 1943). Both veins can be traced for over 700 m along strike. A narrow, discontinuous chalcedony vein that crops out east of the easternmost Sheep Horn calcite vein also contained anomalous concentrations of gold (33 ppb; sample 16 , Table 1). Arkosic sandstones at the base of unit Tsat to the south and east are locally silicified and form the cap to mesas south of Iron Mountain Canyon in secs. 2 and 10, T. 24 S., R. 44 E.

Nonmetallic mineral resources

The calcite veins have been prospected in the past for optical calcite. Bands with pockets of calcite crystals measuring from 1 to as much as 7 in. on a side have been found in the Calcite Miner vein (Lowry, 1943). The crystal surfaces are generally weathered, although clear cleavage fragments as much as 1 in^2 have been reported (Lowry, 1943).

Geothermal resources

Geothermal resources may occur within the quadrangle. A hot spring is shown along the Owyhee River near the mouth of Dry Creek (NW¼SW¼ sec. 16, T. 22 S., R. 44 E.) on the 1921 30-minute topographic map of the Mitchell Butte quadrangle. This is presumably the same spring that is mentioned by Washburne (1909) as being located on the Owyhee River, 15 mi above Deer Butte. The temperature and flow rate of the spring is unknown as it is now covered by waters of Lake Owyhee.

ACKNOWLEDGEMENTS
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EXPLANATION

Qal — **Alluvium (Holocene and Pleistocene)**—Unconsolidated and generally poorly sorted deposits of gravel, sand, and silt along modern streams and flood plains

Qls — **Landslide deposits (Holocene and Pleistocene)**—Landslide and slump deposits of unconsolidated and unstratified soil and angular rock fragments formed as the result of bedrock failure

QTfc — **Colluvial and alluvial fan deposits (Holocene, Pleistocene, and Pliocene?)**—Alluvial fan and slope deposits of unconsolidated coarse gravels and silts, colluvial deposits of scree and talus along slopes of ridges, and accumulations of windblown silt (loess) and sand, mostly of Holocene and late Pleistocene age. Possible Pliocene deposits include alluvial-fan and valley-fill deposits in secs. 22 and 23, T. 23 S., R. 44 E., that have been dissected by Cherry Creek

Tkt — **Tuff of Kern Basin (middle Miocene)**—Mainly nonwelded, fine-grained, white to pale-yellow lithic tuff containing clasts of basalt, banded rhyolite, and white pumice and crystals of biotite, hornblende, quartz, and plagioclase. Includes as many as four nonwelded, light-gray to pale-yellow lithic tuffs interfingering with thin lenses of interbedded tuffaceous and arkosic sandstone and granite-clast conglomerate. Thickness of tuff units increases as thickness of interfingering lithologies decreases from east to west. Lithic clasts, including basalt and flow-banded porphyritic rhyolite, decrease in abundance and diameter from west to east. Juvenile pumice contains biotite, hornblende, quartz, plagioclase, and an opaque iron oxide phase as phenocrysts. The same minerals occur with glass shards and small lithic clasts in the matrix. Tuff deposits include thinly bedded airfall tuffs, cross-bedded surge deposits, chaotically bedded tuff with slump structures, and massive-matrix-supported lithic tuff containing rhyolite and pumice clasts up to 50 cm in diameter. Reverse-graded bedding of pumice clasts and normally graded bedding of rhyolite clasts is apparent in some of the lithic tuffs, which contain pumice clasts as large as 12 cm in diameter. Unit **Tkt** grades upward from thinly bedded airfall tuffs that are locally chaotically bedded with slump structures near the base of the unit, through massive nonwelded lithic tuffs, and up into tuffaceous sandstones with 1-m-thick interbeds of arkosic sandstone and granite-clast conglomerate. Unit thickens to the northwest to a maximum thickness of 100 m on the south flank of Grassy Mountain. Age is middle Miocene, based on a Barstovian fossil (Ferns and Ramp, 1989) and a radiometric K-Ar age determination of 12.6 ± 0.6 Ma on a rhyolite clast (J.J. Rytuba, oral communication, 1990). The unit is interpreted by Storm (1975) as a series of nonwelded ignimbrite flows at the base of the Grassy Mountain Formation. Unconformably overlies unit **Tas**. Equivalent to the lower part of the Kern Basin Formation of Corcoran and others (1962) and the basal tuff breccia of the Grassy Mountain Formation of Kittleman and others (1965). Recognized as the base of the Grassy Mountain Formation by Cummings (1991)

Tas — **Arkose of Dry Creek Buttes (middle Miocene)**—Mainly white to tan arkosic sandstones with minor amounts of granite-clast conglomerate. Includes 6-m-thick, massive beds of coarse, matrix-supported granite-clast conglomerate near exposed base of the unit along the Owyhee River in the Owyhee Dam quadrangle to the northeast (Ferns, 1989). Generally becomes finer grained upward into medium- to coarse-grained micaceous (biotite and muscovite) arkosic sandstone. Locally includes thin interbeds of tuffaceous siltstone and bentonitic clay. Sandstones that cap Burnt Mountain and Nannys Nipple are medium-grained, well-sorted, muscovite-bearing arkose. A conglomerate layer up to 2 m thick and containing granite and gneiss cobbles is interbedded with the arkose near the top of Burnt Mountain. The conglomerate is both clast and matrix supported. Bed forms in the arkose include ripple marks and tabular and minor scour-and-fill cross sets. Arkose occurs in massive layers up to 2 m thick. Thickness of the unit is estimated at 110 m at Nannys Nipple. Low buttes in Oxbow Basin and at Burnt Mountain generally weather to shades of red and are made up of sandstones that have been silicified by introduction of hydrothermal fluids. Unit **Tas** is part of the Deer Butte Formation of Corcoran and others (1962) and Kittleman and others (1965, 1967) and constitutes the arkose of Dry Creek Buttes of the Deer Butte Formation (Cummings, 1991). Locally separated from underlying sequence of Oxbow Basin (units **Tss_{1-8}**) by an angular unconformity (e.g. at Burnt Mountain)

Tss_8, Tss_7, Tss_6, Tss_5, Tss_4, Tss_3, Tss_2, Tss_1 — **Sequence of Oxbow Basin (middle Miocene)**—A sequence of interbedded tuffaceous siltstones and sandstones (units **Tss_7**, **Tss_6**, **Tss_5**, and **Tss_3**), basalt tephra deposits (units **Tss_1**, **Tss_4**, and **Tss_8**), and basalt flows (unit **Tss_2**) named by Cummings (1991). Uppermost unit (**Tss_8**) consists of thick proximal and vent facies deposits of basalt-palagonitic tephra that crop out near the top of Nannys Nipple and at the south end of Burnt Mountain. Complex dikes and sills and, possibly, small, vent-filling basalt flows occur in diatremes and craters in the vents. Finely laminated to massive, light-colored tuffaceous siltstones and fine-grained sandstones of unit **Tss_7** that crop out north of Dry Creek Arm are lacustrine deposits marginal to the vents of unit **Tss_8**. A shallow lacustrine depositional environment is indicated by fish scales and algal mats. Fluvial sediments (unit **Tss_6**) underlie unit **Tss_7** north of Dry Creek Arm, where a coarse-grained arkose distinguished by large-scale scour-and-fill cross bedding forms a layer up to 4 m thick. Matrix-supported conglomerates with small pebbles of granite and quartz occur locally. Channel and sheet deposits of fine-grained tuffaceous siltstones and coarse-grained sandstones (unit **Tss_5**) crop out below unit **Tss_6** east of Burnt Mountain and below the unit **Tss_8** vent on Nannys Nipple. Unit **Tss_5** includes yellow-brown, fine-grained tuffaceous siltstones and sandstones and interbedded lithic-rich channel deposits of coarse sandstones. Moderately well-rounded, granule- to coarse-sand-sized, dark-gray to black clasts of multiply veined, hydrothermally silicified siltstones occur in the channel deposits. Well-sorted sheet sands, cross-bedded at low angle and containing silicified clasts, that occur north of Dry Creek Arm are interpreted to be beach deposits of unit **Tss_5** that grade laterally northward into lacustrine-facies, finely laminated tuffaceous siltstones, and fine-grained sandstones. Fish scales and plant fragments occur in the lacustrine facies of unit **Tss_5**. The base of unit **Tss_5** interfingers with proximal-facies palagonitic tephra deposits of unit **Tss_4**. Unit **Tss_4** vent-facies deposits mark a well-exposed basalt tuff ring north of Dry Creek Arm and west of Burnt Mountain. A tuff cone in unit **Tss_4** is exposed on the south flank of Nannys Nipple. Unit **Tss_4** palagonite tephra deposits overlie light- to medium-gray, organic-rich siltstones of unit **Tss_3**. Unit **Tss_3** includes seams of lignite, siltstones with abundant reed fossils, and fissile shales with interbedded, laminated to massive siltstones. Unit **Tss_3** siltstones lie conformably on basalt-palagonitic tephra deposits of unit **Tss_1** south of Nannys Nipple. The thin basalt flows of unit **Tss_2** (sample V, Table 3) that rest on unit **Tss_1** in the extreme southwest corner of the quadrangle may be correlative with the unit **Tbou** flows exposed on the east side of Lake Owyhee. Unit **Tss_1**, the stratigraphically lowest unit in the sequence of Oxbow Basin, includes (1) massive basaltic tephra deposits containing blocks of vesicular to massive basalt in a palagonite matrix and interbedded with tuffaceous siltstones and (2) moderately well-bedded tephra deposits containing palagonitized ash and lapilli, basalt lithic fragments, and accretionary lapilli. Proximal-, intermediate-, and vent-facies deposits are common (Cummings and Growney, 1988). Tephra deposits of units **Tss_1**, **Tss_4**, and **Tss_8** were formed during explosive interactions between basalt magma and surface or ground water. The sequence of Oxbow Basin (Cummings, 1991, and unpublished mapping, 1987-1988) is part of the Deer Butte Formation of Corcoran and others (1962) and Kittleman and others (1965, 1967)

Tbb — **Basalt and basaltic andesite? flows (middle Miocene?)**—Mainly gray to black, generally holocrystalline, aphyric and plagioclase-phyric basalt flows that fill paleocanyons eroded into the underlying basalt unit **Tbo** north of Lake Owyhee. The unit thins progressively southeastward from a maximum thickness of 100 m in the northwest corner of the quadrangle to a single flow on Sheephead Ridge. Includes a well-exposed pillow delta complex in the SE¼ sec. 34, T. 22 S., R. 44 E., where palagonitic rinds occur on pillows. Flows are pilotaxitic to ophitic and characterized by plagioclase phenocrysts less than 3 mm in length and microphenocrysts of clinopyroxene, orthopyroxene, and iddingsitized olivine. Distinguished from underlying flows of units **Tbo** and **Tbou** by a generally fresher appearance on weathered surfaces, thinner weathering rinds, commonly holocrystalline groundmass, and relatively greater abundance of olivine and orthopyroxene phenocrysts. Samples A and P in Table 2 and samples from presumably correlative capping flows in the Owyhee Ridge quadrangle (Ferns, 1988), Owyhee Dam quadrangle (Ferns, 1989), and near Dry Creek to the south (Hart, 1981; Cummings, 1991) are calc-alkaline basalts and basaltic andesites. K-Ar age determinations for presumably equivalent flows in the Owyhee Dam and Grassy Mountain quadrangles (Ferns, 1989; Ferns and Ramp, 1989) range from 8.67 to 16.1 Ma (Fiebelkorn and others, 1982; Hart and Carlson, 1983). D.B. Vander Meulen (written communication, 1989) reports a K-Ar whole-rock age of 12.8 ± 0.4 Ma from the unit's basal flow on the east side of Owyhee Ridge in the Owyhee Ridge quadrangle to the northeast. Capping flow in sec. 19, T. 23 S., R. 45 E., has been dated at 10.3 ± 1.1 Ma (J.J. Rytuba, oral communication, 1990). Equivalent to the Blackjack Basalt of Bryan (1929) and Geldsetzer (1966) and the Deer Butte basalts and uppermost flows of the Owyhee Basalt as mapped by Kittleman and others (1965) and Corcoran and others (1962). Cummings (unpublished mapping, 1987-1988) refers to similar flows north of Dry Creek in the Twin Springs quadrangle as part of the sequence of Freezeout Creek. New analytical data indicate that previous correlations with the 12-flow sequence of Cummings and Growney (1988) in Ferns and Ramp (1989) are incorrect. The basalt of the 12-flow sequence of Cummings and Growney (1988) is tholeiitic basalt rather than calc-alkaline basaltic andesite

Tass — **Tuffaceous sandstones and siltstones (middle Miocene)**—Mainly light-colored, thin-bedded, fine-grained tuffaceous siltstones with interbedded white tuffaceous sandstones. Includes thin-bedded, brown silty sandstones and interbedded gypsiferous bentonitic claystones. Also includes coaly shales and fine-grained volcanic sandstone. Crops out along the west side of Lake Owyhee between flows of units **Tbb** and **Tbo**

Tbou — **Owyhee Basalt, upper flows (middle Miocene)**—Basalt and basaltic andesite flows. Mainly flow-on-flow sequence of olivine-phyric basalt that caps ridges north and south of Cherry Creek. Includes plagioclase-phyric basaltic andesites and interbedded pyroclastic deposits. Separated from the type section of Owyhee Basalt by tuffaceous sediment (unit **Tsu**) north of Cherry Creek and interpreted as being slightly younger than the type section. Chemically indistinguishable from the main section of Owyhee Basalt exposures, consisting of calc-alkaline basalts and basaltic andesites (samples F, H, J, K, L, M, and Q, Table 2). Discontinuous outcrop pattern and irregularly shaped lower contact suggest that the flows were deposited on an irregular surface. One probable vent area is delineated by the dike complex exposed on the northeast branch of Cherry Creek in sec. 13, T. 23 S., R. 44 E., where red scoria deposits in unit **Tsu** interfinger with unit **Tbou** flows. Equivalent to the upper part of the Owyhee Basalt as mapped by Corcoran and others (1962) and, in part, to olivine basalt flows in the Deer Butte Formation (Corcoran and others, 1962; Kittleman and others, 1967). May be equivalent to unit **Tss_2** flows in the southwest corner of the quadrangle

Tbo — **Owyhee Basalt, basalt, basaltic andesite, and andesite (middle Miocene)**—Mainly dark-gray to black, fine-grained platy plagioclase-phyric lava flows and autoclastic breccias that weather to shades of red and brown. Includes generally thin, lenticular subaerial tuff, red and black scoria deposits, and orange-brown palagonitic tuff. In The Elbow quadrangle, unit consists mainly of distinct stacks of thin (1.5-m-thick) basalt flows and platy basaltic andesite flows (3-7 m thick). In thin section, pilotaxitic textures are predominant. Phenocryst assemblages are mainly plagioclase and plagioclase + olivine + clinopyroxene. Olivines are usually altered to iddingsite or to a bright-green mineral (bowlingite?). Chemically, mainly calc-alkaline basalts, basaltic andesites, and andesites (Brown and Petros, 1985) (samples D, G, and I, Table 2). Radiometric K-Ar age determinations for the Owyhee Basalt range from 14.1 to 25.3 ± 1.8 Ma (Fiebelkorn and others, 1982; Brown and Petros, 1985). Field relations determined in this quadrangle suggest that the previous interpretation by Ferns (1988, 1989) and Ferns and Ramp (1989) that unit **Tbo** is older than the 15.5-Ma ash-flow tuffs in the Owyhee Ridge and Pelican Point quadrangles is in error

Tbol — **Owyhee Basalt, lower flows (middle Miocene)**—Basalt and basaltic andesite flows. Includes uppermost flows of scoriaceous olivine basalt. Lowest exposed part of the unit consists of a 14-m-thick andesite flow that drapes around a constructional topography made up of hydrovolcanic vents of underlying unit **Tos**. Overlain by unit **Tdr**. Chemically and petrographically indistinguishable from flows in unit **Tbo** (samples A, B, and E, Table 2). Herein considered to be the lower part of the Owyhee Basalt of Bryan (1929)

Tsu — **Sucker Creek Formation, undifferentiated (Miocene)**—Mainly fine-grained, light-orange-brown, tuffaceous, palagonite-rich volcaniclastic silt- and sandstones and pale, yellowish-white zeolitized tuffs. Tuffs include white, zeolitic tuff breccias. Silt- and sandstones include yellowish-brown palagonitic sandstones and tuffaceous volcaniclastic conglomerates with scoriaceous clasts and yellow-white pumiceous lapilli tuffs. Unit also includes interbeds of (1) coarse-grained, felsic, light-colored lithic tuffs composed of white inflated pumice and aphyric black basalt clasts and (2) vent- and proximal-facies mafic lapilli tuffs, steeply dipping red scoria deposits, and yellow-brown palagonitic tuffs. Northernmost exposures interfinger with unit **Tbou** flows near the head of Cherry Creek. Generally becomes finer grained upsection and to the south. A white, pumiceous, nonwelded lithic ash-flow tuff with petrified wood crops out near the top of the section south of Board Corral Springs. Considered part of the Sucker Creek Formation (Kittleman and others, 1965, 1967) and equivalent to unit **Tsu** as mapped by Ferns (1988) in the Owyhee Ridge quadrangle to the northeast. May in part be equivalent to unit **Tss_1**

Tsat — **Arkose and tuffaceous sandstones, siltstones, and tuff (middle Miocene)**—Sedimentary sequence of channel-fill consisting of muscovite-bearing arkose and overlying white air-fall and water-lain zeolitized tuff. Includes interbedded lithic tuff and orange palagonitic siltstones. Conformably overlain by unit **Tsu**. Equivalent, in part, to arkosic sandstones mapped as unit Tp by Vander Meulen and others (1987) in the adjacent Pelican Point quadrangle to the south. Silica-cemented fine- to coarse-grained, channel-fill arkosic sandstones at the base of the unit form prominent outcrops east of Iron Mountain. Massively bedded, well-sorted, muscovite-bearing sandstones contain large wood fragments and rip-up clasts of underlying palagonitic siltstones

Tsv — **Basaltic andesite (middle Miocene)**—A single intracanyon flow of gray to bluish-gray, aphyric, platy basaltic andesite with a well-preserved cap of red scoria. Fills a topographic depression cut into underlying unit **Tso** and is conformably overlain by unit **Tsat**. Chemically a calc-alkaline basaltic andesite (samples S and T, Table 2). Dated at 13.8 ± 0.5 Ma (J.J. Rytuba, oral communication, 1990)

Tdr — **Plagioclase rhyodacite (middle Miocene)**—Flow-foliated, red, plagioclase-phyric rhyodacite flow of variable thickness. The massive portion of the flow is as much as 120 m thick in the quadrangle. Massive parts of flow are commonly vertically jointed. The rhyodacite locally has a vitrophyre base and a rubbly carapace of vitrophyre blocks in an ash matrix. Petrographically, a glassy rhyodacite with about 2 percent embayed plagioclase phenocrysts and small, partially resorbed orthopyroxene phenocrysts. An analysis of the vitrophyre base (sample C, Table 2) indicates a rhyodacite composition. A K-Ar age determination of 13.5 ± 3.4 Ma (J.J. Rytuba, oral communication, 1990) better agrees with the observed stratigraphy than the 22.8 ± 2.6-Ma K-Ar age determination by Brown and Petros (1985). The rhyodacite underlies flows of the Owyhee Basalt (unit **Tbo**) and overlies hyaloclastite deposits (unit **Tos**) at the Owyhee Resort and the lower calc-alkaline flow unit of Owyhee Basalt (unit **Tbol**) along the western edge of Lake Owyhee. Interpreted as a silicic calc-alkaline flow dome formed during early eruptions of Owyhee Basalt. The vent area is presumed to be marked by the thick accumulation of rhyodacite along the dam abutments in the Owyhee Dam quadrangle to the north

Tos — **Palagonitic lapilli tuffs and laharic breccias (middle Miocene)**—Mainly brown to light-orange-brown coarse- to medium-grained palagonitic breccias containing plagioclase-phyric and aphanitic mafic volcanic clasts up to 0.6 m in diameter. Includes orange-brown to brown, massive-matrix-supported lahars with basalt and tuff clasts and clast-supported, thin-bedded surge deposits with palagonite accretionary lapilli. Steeply dipping deposits that often weather to hoodoos define local hydrovolcanic eruptive centers. Steeply inward dipping deposits south of Cherry Creek and on the southwest flank of Sheephead Ridge are presumed to mark tuff rings. Derived from hydrovolcanic eruptions resulting from introduction of basalt magma into a water-saturated environment. Basalt lahar in Iron Mountain Canyon contains clasts of rhyolite porphyry and rip-ups of coaly shales and arkosic sandstones from underlying unit **Tsts**. Unit varies in thickness with a maximum thickness estimated at about 135 m at vent areas. The top of the unit locally interfingers with the base of units **Tbo** and **Tdr**. Correlative with unit **Tos** as mapped in the Owyhee Ridge and Owyhee Dam quadrangles (Ferns, 1988, 1989) and the lower part of the Sucker Creek Formation (Corcoran and others, 1962; Kittleman and others, 1965, 1967)

Tsts — **Silicic tuffs and interbedded sedimentary rocks (middle Miocene)**—Lower part of unit southwest of Sheephead Ridge consists of 1- to 4-m-thick beds of white zeolitic airfall tuff with 0.75- to 1.5-m-thick interbeds of dark blackish-brown coaly shales. Section here is capped by a 20-m-thick sequence of laminated, orange-brown palagonitic volcaniclastic sandstones. Unit to the west contains a 2-m-thick, nonwelded lapilli tuff with pumice clasts. Interbeds include coaly shales and channel-fills of coarse-grained, cross-bedded, muscovite-bearing arkose sandstones. Unconformably overlain in Iron Mountain Canyon by massive lahars of unit **Tos**

Tbi, Tbi_1 — **Basalt, basaltic andesite, and andesite dikes, sills, and shallow intrusions (Miocene)**—Basalt, basaltic andesite, and andesite plugs, sills, and dikes. Includes glassy, columnar-jointed, glomeroporphyritic olivine basalts, such as the plug at Iron Mountain (sample U, Table 2), and large masses of platy-jointed, plagioclase-phyric basalts and basaltic andesites emplaced as irregularly shaped dikes and sills in and adjacent to palagonite tuff units **Tos** (sample N, Table 2), **Tss_1**, and **Tss_5** (samples OW-603 and OW-1407, Table 3). Also includes coarse-grained, holocrystalline olivine basalt sills with ophitic textures that form poor exposures and weather to granular, orange-brown soils (samples O and T, Table 2). Coarse clots of ophitic clinopyroxene give weathered surfaces a mottled appearance. The intrusions are interpreted to have been feeders to hydrovolcanic deposits of units **Tos**, **Tss_1**, **Tss_4**, and **Tss_8** and to various unit **Tbo** flows. Where determined, younger dikes that cut across older intrusions are identified as unit **Tbi_1**. Dikes and small, irregularly shaped intrusive masses are concentrated in or adjacent to hydrovolcanic eruptive centers and are generally aligned along a north-northeast trend, parallel to regional faults, while the larger, more glassy intrusions appear to stretch out along a more northeasterly trend. Some of the sills along both sides of Lake Owyhee in the southeast corner of the quadrangle may be invasive unit **Tbou** flows

MAP SYMBOLS

Contact — approximately located.

Fault contact — dashed where approximately located, dotted where concealed; ball and bar on downthrown side

Fold axis

Strike and dip of beds

Trend of calcite vein

Location of sample analyzed in Table 1

Location of sample analyzed in Table 2

Location of sample analyzed in Table 3

Location of sample analyzed in Table 4

Vertebrate fossil locality

GEOLOGIC CROSS SECTIONS