STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DONALD A. HULL, STATE GEOLOGIST

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

1992

ISSN 0270-952X

GMS-69

Geology and Mineral Resources Map of the Harper Quadrangle, Malheur County, Oregon
By M.L. Ferns and J.P. O'Brien

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

Base map by U.S. Geological Survey
Control by USGS and NOS/NOAA
Topography compiled from aerial photographs taken 1964, revised from aerial photographs taken 1985, field checked 1987, edited 1990.
Lambert Conformal Conic Projection. 1927 North American datum 10,000-foot grids based on Oregon coordinate system, south zone.
1000-meter Universal Transverse Mercator grid ticks, zone 1

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
SUPPLEMENTARY CONTOUR INTERVAL 20 FEET

QUADRANGLE LOCATION

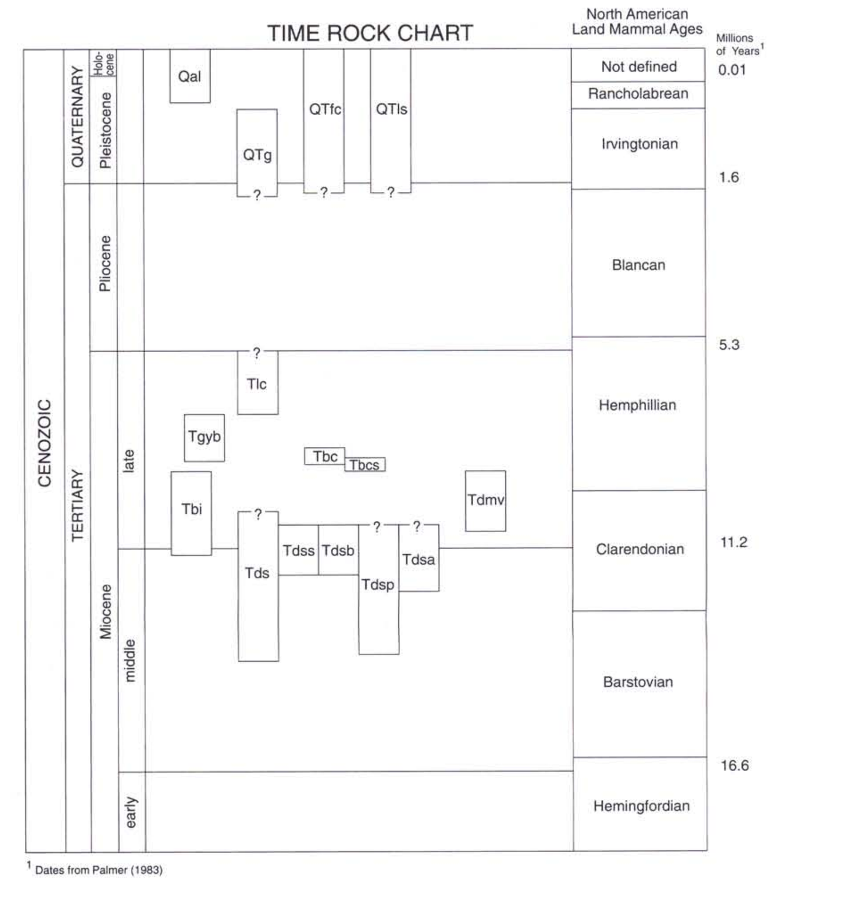
Geology by Mark L. Ferns and James P. O'Brien,
Oregon Department of Geology and Mineral Industries

Field work conducted in 1990

Reviewed by James G. Rytuba, U.S. Geological Survey; and
Ronald P. Geitgey, Oregon Department of Geology and Mineral Industries

Acknowledgments: The analytical discussion was prepared by Gary L. Baxter, Geochemist, Oregon Department of Geology and Mineral Industries.

Cartography by Allan Cartography



[1] Dates from Palmer (1983)

EXPLANATION

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

QTfc — **Colluvial and alluvial fan deposits (Holocene, Pleistocene, and Pliocene?)**—Mainly alluvial fan and slope deposits consisting of unconsolidated coarse gravels and silts. Colluvial deposits include scree and talus along slopes of ridges and thick accumulations of windblown silt (loess) and sand on benches and ridges. Includes coarse, unconsolidated basaltic gravels mantling the top of unit **Tdmv** basalt flows east of Fenceline Spring in secs. 13 and 14, T. 20 S., R. 42 E., that may be derived from weathering of postbasalt, upper Miocene sedimentary deposits of unit **Tic**

QTls — **Landslide deposits (Holocene, Pleistocene, and Pliocene?)**—Unconsolidated and nonstratified deposits of soil and angular blocks of basalt. Characterized by a hummocky topography. Main landslides have developed where basalt of unit **Tdsb** locally overlies fine clayey shales in unit **Tdss**. Older landslide deposits north of Winter Spring that lie on the highest terraces of unit **QTg** have been dissected by modern drainage systems

QTg — **Terrace gravels and interbedded tuffaceous lacustrine sedimentary rock (Pleistocene and Pliocene?)**—Mainly subhorizontally bedded, poorly consolidated fine- to coarse-grained conglomerates with rhyolite and basalt clasts. Includes fine-bedded, drab greenish-brown bentonitic clays with disseminated gypsum crystals. Friable, medium-grained, pebbly, arkosic sandstones exposed south of the gravel pit in sec. 8, T. 20 S., R. 42 E., are locally calcite-cemented and contain well-rounded clasts of vitrophyre and chalcedonic quartz. Similar semiconsolidated sandstones with angular fragments of petrified wood are exposed below the landslide deposits north of Winter Spring. Terrace gravels along the west side of Cottonwood Creek contain rounded basalt and rhyolite clasts up to 1 ft in diameter. At least three terrace levels are preserved east of Cottonwood Creek, where the upper terrace at 2,800-ft elevation is overlain by landslide debris. Individual terrace deposits vary from several feet to nearly 80 ft in thickness. Age based on middle Pliocene mammalian fossils at University of Oregon Locality 2342 (Weeden, 1963)

Tic — **Tuffaceous sedimentary rocks (Pliocene? to upper Miocene)**—Mainly pale-yellow to yellowish-white, fine-grained tuffaceous siltstones. Exposed only along the south side of U.S. Highway 20 in sec. 35, T. 19 S., R. 42 E., where an erosional remnant of locally thin-bedded tuffaceous shales lies on unit **Tgyb** and is overlain by gravels of unit **QTg**. Believed to be equivalent to unit Tis as mapped by Brooks (1991) in the Vines Hill quadrangle to the northeast. Herein presumed to be equivalent to tuffaceous siltstones overlying unit Trsb in the Kane Springs Gulch quadrangle to the east (Urbanczyk and Ferns, unpublished mapping, 1989). Unconsolidated silts and gravels of unit **QTfc** in secs. 13 and 14, T. 20 S., R. 42 E., may be derived from unit **Tic**

Tgyb — **Olivine basalt (upper Miocene)**—Mainly bluish-black to black olivine basalt flows. Locally includes pillow basalts and palagonite breccias. Unit thickens from a single thin flow with a laterally extensive palagonite breccia in the southern part of the quadrangle to at least three separate flows exposed north of Buckaroo Cabin in sec. 25, T. 20 S., R. 42 E. A north-dipping pillow delta exposed south of Buckaroo Cabin indicates a north-to-south flow direction. Individual flows are typically hyalophitic to subophitic with plagioclase and olivine phenocrysts. At least one flow contains partially resorbed quartz xenocrysts. Includes quartz tholeiites with K_2O abundances of 0.90 percent and greater (samples B and E, Table 1). Maximum thickness of unit is estimated to be about 200 ft. Flows are the upper part of the Grassy Mountain Basalt of Bryan (1929) and the Grassy Mountain Formation of Kittleman and others (1965). Olivine basalt flows of unit **Tgyb** may be time-correlative to the olivine tholeiite flows of unit Trsb mapped by Ferns and Ramp (1989) and Urbanczyk and Ferns (unpublished mapping, 1989) to the east

Bully Creek Formation (upper Miocene)

Tbc — **Tuffaceous sedimentary rocks (upper Miocene)**—Mainly massively bedded, pale yellowish-white tuff with interbedded tuffaceous siltstone and diatomite. Includes an interbedded, gray vitric tuff layer about 3 ft thick southeast of Buckaroo Cabin. Also includes tuffaceous sandstones with volcanic-clast conglomerate lenses and very thin-bedded, fine-grained pinkish-red shales with root and plant fragments. May be correlative to unit Tis of Ferns and Ramp (1989) in the Grassy Mountain quadrangle to the southeast. Northernmost exposures along Highway 20 can be traced northward into the Bully Creek Formation of Kittleman and others (1965, 1967). Grades eastward and southward into the underlying fine-grained arkose sandstones of unit **Tbcs**

Tbcs — **Arkosic sandstones and siltstones (upper Miocene)**—Mainly white, fine-grained sandstones with interbedded pinkish-red shales and popcorn-weathering claystones. Sandstones are generally fine- to medium-grained, friable arkoses and lithic arkoses with approximately equal amounts of angular to subangular grains of quartz and feldspar. Biotite, muscovite, and garnet are common accessory minerals. Unit is best exposed on Basin Creek at the old Blue Moon uranium prospect, where over 400 ft of interbedded arkosic sandstones and shales are exposed. Unit locally includes fine-grained claystones with scattered aggregates of gypsum crystals. Fine-grained arkose sands in the southeastern corner of the quadrangle near Stacey Reservoir Number 2 are interbedded with diatomite. Sandstones are silicified in secs. 3 and 10, T. 21 S., R. 42 E. Unit was mapped earlier as part of the Grassy Mountain Formation of Kittleman and others (1965) but is herein interpreted as a coarser grained shoreline facies of the Bully Creek Formation

Tdmv — **Basaltic andesites (upper Miocene)**—Mainly dark blackish-blue, plagioclase-phyric, hypersthene-bearing basaltic andesite flows that weather to shades of red. Generally hyalophitic with plagioclase, hypersthene, and occasional olivine phenocrysts in a groundmass comprised of smaller plagioclase laths set in a glass charged with fine opaques. Includes basaltic andesites (samples A and C, Table 1) with 54 percent SiO_2. Continuous with the unit Tdmv flows mapped by Urbanczyk and Ferns (unpublished mapping, 1989) to the east and equivalent to the unit Tui flows of Storm (1975) and the unit Tdmv flows of Brooks (1991) in the Vines Hill quadrangle to the northeast. Part of the Grassy Mountain Formation of Kittleman and others (1965)

Drip Springs Formation (upper to middle Miocene)

Tdss — **Arkosic sandstones and conglomerates (upper to middle Miocene)**—Mainly white to pale-yellow, fine-, medium-, and coarse-grained massive and cross-bedded arkosic sandstones. Where poorly to moderately indurated, sandstones weather to a hoodoo topography when capped by resistant units. Unit includes tuffaceous siltstone and gypsiferous, bentonitic claystone interbeds. Southernmost exposures on Keeney Creek are interbedded with basalt lava flows of unit **Tdsb**. Generally fines upward from medium-grained pebble conglomerates and coarse-grained, cross-bedded arkosic sandstones to gray and white tuffaceous siltstones. Sandstones typically are comprised of approximately equal amounts of angular to subangular quartz and feldspar grains and volcanic and plutonic rock fragments. Accessory minerals include biotite, muscovite, and garnet. Banded and massive rhyolites are the most common lithic clasts in the conglomerates. Resistant outcrops interbedded with basalt flows in the main area of exposure west of Keeney Creek are silicified. Silicified arkoses also crop out adjacent to the exhalative chert deposits of unit **Tdsa** in secs. 3 and 10, T. 20 S., R. 42 E. Weakly silicified, iron-stained exposures crop out along the west bank of Cottonwood Creek in sec. 16, T. 20 S., R. 42 E. Composite thickness of units **Tdss** and **Tdsb** is estimated at about 700 ft. Unit is equivalent to the uppermost part of the Squaw Creek Formation as mapped by Weeden (1963), which was later renamed Drip Springs Formation by Kittleman and others (1965)

Tdsb — **Basalt and basaltic andesite (upper to middle Miocene)**—Fine-grained, aphyric platy basalt flows that are locally interbedded with arkose sandstones of unit **Tdss**. Generally dark grayish-black on fresh surfaces. Main area of exposure west of Keeney Creek is composed of easily eroded outcrops of hydrothermally altered basalts that weather to shades of brown and green and are locally cut by iron-stained chalcedony stringers. Includes aphyric basalts with 4-mm-long plagioclase laths, 1-mm-long intergranular olivine crystals, and ophitic to subophitic clinopyroxenes. The one analyzed sample is a quartz tholeiite with relatively high K_2O (sample D, Table 1). Samples from the Keeney Ridge quadrangle to the south (Ferns and O'Brien, unpublished mapping, 1990) are basalts whose major- and trace-element abundances are nearly identical to those for the Owyhee Basalt (Brown and Petros, 1985; Ferns and Cummings, unpublished mapping, 1989). The basalts are considered to be part of the Grassy Mountain Formation by Weeden (1961, 1963) and Kittleman and others (1965)

Tdsa — **Silicified siltstones and exhalative chert deposits (upper? to middle Miocene)**—Strongly silicified tuffs, arkosic sandstones, and thin-bedded, gray-black cherts. Includes accumulations of gray to black chert and chert breccias as much as 40 ft thick. Thick sequences of silicified tuff in secs. 3 and 10, T. 20 S., R. 42 E., are layered accumulations of massive, dense, iron-stained, orange to greenish-yellow, pyritic chalcedonic quartz. Layered cherts locally display soft sediment folds and weakly silicified, clast-supported breccias that may record penecontemporaneous downslope movement from vent areas. Unit **Tdsa** in sec. 10 includes overlying medium-grained, silicified arkose sandstones with rare lensoid pods of silicified tuff and chert 2 ft in diameter. Other areas of unit **Tdsa** too small to map include two exposures in the bed of Keeney Creek (samples 13 and 16, Table 2) and a zone along the contact between units **Tds** and **Tdsp** in sec. 18, T. 20 S., R. 42 E. Exhalative chert deposits are interpreted to represent the surface of subaqueous hot spring systems active during deposition of unit **Tds** tuffs after eruption of the unit **Tdsp** hyaloclastite deposits

Tdsp — **Palagonitic lapilli tuffs and laharic breccias (upper? to middle Miocene)**—Reddish- and yellowish-brown palagonitic lapilli tuffs, breccias, and volcaniclastic sandstones. Mainly bedded deposits of lithic lapilli tuff with zeolitized plagioclase crystals and angular to rounded clasts of basalt, tuff, accretionary lapilli, and rare diatomite in a matrix of altered basaltic glass, zeolite, and calcite. Includes orange-brown to brown, massive, matrix-supported lahars with basalt and tuff clasts and clast-supported, thin-bedded surge deposits with accretionary palagonite lapilli. A section over 300 ft thick is exposed along the west bank of Cottonwood Creek in sec. 31, T. 20 S., R. 42 E., where a structurally high area is characterized by radiating dips. This appears to be a tuff cone that is one of the vent areas that may be a source for the bedded hyaloclastite deposits to the north. Minimum of 300 ft of palagonite breccias with vesicular aphyric basalt clasts are exposed in the NW¼ sec. 4, T. 21 S., R. 42 E.

Tds — **Tuffaceous siltstones (upper? to middle Miocene)**—Mainly tuffaceous and palagonitic siltstones and sandstones. Main area of exposure is comprised of massive, orange-weathering tuffaceous sandstones and siltstones that are white to yellowish white on fresh surfaces. Unit includes thin-bedded, white siliceous tuffs that are iron stained along bedding and joint surfaces. Approximately 400 ft of thin-bedded, white siliceous tuffs are exposed between the hyaloclastite deposits of unit **Tdsp** and arkosic sandstones of unit **Tdss** along the west bank of Cottonwood Creek in sec. 20, T. 20 S., R. 42 E. X-ray diffraction analyses of the white siliceous tuffs yielded broadened peaks of partially disordered cristobalite, indicating conversion to a form referred to as opal-CT (Jones and Segnit, 1971). Named by Kittleman and others (1965) for exposures at Drip Springs in the Avery Creek quadrangle to the southwest

Tbi — **Mafic intrusives (upper to middle Miocene)**—Dark-black to grayish-black olivine basalt dikes and sills. Sills characterized by thick upper glassy margins that readily weather to granular slopes. Upper contacts also marked by apophyses and detached pods of glassy basalt incorporated into adjacent palagonitic country rock that were described as peperite intrusions by Weeden (1963) and Kittleman and others (1965). Crystalline interiors are typically coarse-grained olivine basalts with ophitic textures

MAP SYMBOLS

Contact—Approximately located

Fault—Dashed where approximately located; dotted where concealed; ball and bar on downthrown side; dips shown where observed or known

Lineament—Prominent linears in Quaternary deposits that may indicate Recent faulting

Strike and dip of beds or flows

Trend of anticlinal fold axis

Location of sample analyzed in Table 1

Location of sample analyzed in Table 2

MINERAL RESOURCES

Gold is the main potential mineral resource in the quadrangle. Several areas with exhalative chert deposits (e.g., secs. 3 and 10, T. 20 S., R. 21 E., and secs. 5 and 6, T. 21 S., R. 42 E.) that may be surface indications of subaqueous hot springs contain slightly anomalous amounts of arsenic, antimony, and mercury. Trace amounts of gold (2-33 ppb) occur in surface samples from the main alteration zones in secs. 3 and 10, T. 20 S., R. 42 E. Some of the highest trace-element levels (788 ppm As, 4.85 ppm Sb) were detected in a sample from a narrow manganese vein cutting silicified sandstones of unit Tbcs in sec. 3, T. 21 S., R. 42 E.

Relatively high levels of mercury that occur in samples of cherts and chalcedonic stringers from arkose sandstones and basalts along Keeney Creek in the southwest part of the quadrangle may delineate another hydrothermal system. Some samples from the southern part of the quadrangle also contain anomalous amounts of thallium (samples 13 and 15, Table 2). Additional areas of hydrothermal activity occur west of Cottonwood Creek in secs. 16 and 17, where iron-stained siliceous tuffs (converted to opal-CT?) of unit Tds crop out. Indurated, iron-stained sandstones of overlying unit Tdss to the east may indicate a buried system near here. Chalcedonic veins that occur along faults in unit Tds at the north end of sec. 18, T. 20 S., R. 42 E., may be feeders to the exhalative cherts that are exposed immediately south of Highway 20 in sec. 7, T. 20 S., R. 42 E.

Although uranium prospects have been located in the quadrangle in the past, no uranium resources were recognized during this project. The two prospects, the Blue Moon (SW¼ NE¼ sec. 22, T. 20 S., R. 42 E.) and the Blue Star (NE¼ NE¼ sec. 11, T. 21 S., R. 42 E.) that were located in 1954, are located in friable sandstones and tuffaceous siltstones of units Tbca and Tbc. According to unpublished reports of the Oregon Department of Geology and Mineral Industries (DOGAMI) (Wagner, 1954), low-level radioactivity at the prospects was associated with scattered, weakly silicified limonitic streaks cutting the sands and tuffs.

The arkosic sandstones in units Tbcs and Tdsa may be potential silica sand resources. Friable sands exposed at the Blue Moon uranium prospect were tested by Geitgey (1990), who reported values for two raw samples of 74.2 and 85.5 percent SiO_2. White, friable sandstone outcrops of unit Tbcs in the southeast corner of the quadrangle in sec. 11, T. 21 S., R. 42 E., weather to a white granular sand that may be usable as a silica sand source.

Although geothermal resources have not been delineated in the quadrangle, known hot springs occur within 1 mi of the quadrangle boundary. Temperatures of 69°C and 70°C are reported from hot springs and wells in sec. 30, T. 19 S., R. 41 E. (Oregon Department of Geology and Mineral Industries, 1982). Similar temperature subsurface waters that may be suitable for space heating purposes may be expected to occur within the quadrangle.

GROUND-WATER RESOURCES

Unconsolidated gravels in unit Qal along the Malheur River and Cottonwood Creek hold the main ground water resource in the quadrangle. Friable sands of units Tdss and Tbcs locally act as aquifers where capped by impermeable clays or basalts. Spring lines are developed along Basin Creek and east of Cottonwood Creek, where the friable sands are overlain by basalt flows.

GEOCHEMISTRY

Sample preparation

Samples for whole-rock analysis (Table 1) were crushed to minus ¼-in. in a steel-jawed Braun chipmunk crusher and split in a Jones-type splitter in the Oregon Department of Geology and Mineral Industries (DOGAMI) laboratory. A split of about 60 g was ground to minus 200 mesh in agate media by X-ray Assay Laboratories (XRAL) of Don Mills, Ontario, Canada.

Samples for trace-element analysis of altered rocks (Table 2) were crushed to minus ¼-in. and split as indicated above to obtain a nominal 250-g subsample. Each subsample was milled to about minus 200 mesh in chrome-steel media in an Angstrom disc mill in the DOGAMI laboratory. Each milled subsample was split again to produce two analytical samples: one to determine gold and one to determine the other trace elements.

Chemical analysis

Whole-rock analysis: X-ray fluorescence (XRF) analyses (Table 1) were performed by XRAL. XRAL used a fused button for its analyses (1.3 g of sample roasted at 950°C for one hour, fused with 5 g of lithium tetraborate, and the melt cast into a button). Loss on ignition (LOI) was determined from weight loss during roasting.

Trace-element analysis:

1. Gold — Bondar-Clegg, Ltd., of North Vancouver, British Columbia, performed the analyses for gold. The method employed was fire-assay preconcentration of the gold in a 20-g sample (gold was collected in added silver), acid dissolution of the resulting bead, and a direct current plasma (DCP) emission spectrometer finish. The detection limit was 1 part per billion (ppb).

2. Fourteen trace elements — Geochemical Services, Inc., (GSI) of Sparks, Nevada, performed the analyses for 14 trace elements. The method employed a proprietary acid dissolution/organic extraction of a 5-g sample. The finish was by induction coupled plasma (ICP) emission spectrometry. GSI considers the digestion to provide total metal contents except for gallium and thallium.

3. Eight trace elements — The DOGAMI laboratory performed the analyses for eight elements: barium, cobalt, chromium, iron, lithium, manganese, nickel, and tungsten. For the first seven elements, a 1-g sample was digested with nitric and hydrofluoric acids, the solution taken to near-dryness with perchloric acid, and the residue redissolved and taken to 100-ml volume with 10-percent nitric acid. The finish was by flame atomic absorption and (for lithium) flame emission spectrometry. The digestion provides total metal content except for barium and possibly chromium. Tungsten was determined by a method that gives semi-quantitative results: 1/4 g of sample fused with potassium pyrosulfate and dissolved with hydrochloric acid, an aliquot treated with stannous chloride and zinc dithiol, the tungsten extracted into 0.5 ml amyl acetate, and the colored complex visually compared with standards. The detection limit for tungsten was 5 ppm.

REFERENCES

Brooks, H.C., 1991, Geology and mineral resources map of the Vines Hill quadrangle, Malheur County, Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-63, 1:24,000.

Brown, D.E., and Petros, J.R., 1985, Geochemistry, geochronology, and magnetostratigraphy of a measured section of the Owyhee Basalt, Malheur County, Oregon: Oregon Geology, v. 47, no. 2, p. 15-20.

Bryan, K., 1929, Geology of reservoir and dam sites, with a report on the Owyhee irrigation project, Oregon: U.S. Geological Survey Water-Supply Paper 597-A, 72 p.

Ferns, M.L., and Ramp, L., 1989, Geology and mineral resources map of the Grassy Mountain quadrangle, Malheur County, Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-57, 1:24,000.

Geitgey, R.P., 1990, Silica in Oregon: Oregon Department of Geology and Mineral Industries Special Paper 22,18 p.

Jones, J.B., and Segnit, E.R., 1971, The nature of opal: I. Nomenclature and constituent phases: Journal of the Geological Society of Australia, v. 18, pt. 1, p. 57-67.

Kittleman, L.R., Green, A.R., Haddock, G.H., Hagood, A.R., Johnson, A.M., McMurray, J.M., Russell, R.G., and Weeden, D.A., 1967, Geologic map of the Owyhee region, Malheur County, Oregon: Eugene, Oreg., University of Oregon Museum of Natural History Bulletin 8, 1:125,000.

Kittleman, L.R., Green, A.R., Hagood, A.R., Johnson, A.M., McMurray, J.M., Russell, R.G., and Weeden, D.A., 1965, Cenozoic stratigraphy of the Owyhee region, southeastern Oregon: Eugene, Oreg., University of Oregon Museum of Natural History Bulletin 1, 45 p.

Oregon Department of Geology and Mineral Industries (DOGAMI), 1982, Geothermal resources of Oregon, 1982: DOGAMI/National Oceanic and Atmospheric Administration (for U.S. Department of Energy), one map, 1:500,000.

Palmer, A.R., 1983, The Decade of North American Geology 1983 geologic time scale: Geology, v. 11, no. 9, p. 503-504.

Storm, A.B., 1975, Stratigraphy and petrology of the Grassy Mountain Formation (Hemphillian, middle Pliocene), Malheur County, Oregon: Eugene, Oreg., University of Oregon master's thesis, 63 p.

Wagner, N.S., 1954, Blue Moon uranium claims: Unpublished report on file at Oregon Department of Geology and Mineral Industries (Malheur County), 3 p., 1 sketch map.

Weeden, D.A., 1961, Geology of the Harper Basin area, Oregon: Preliminary report: Oregon Department of Geology and Mineral Industries unpublished report, 39 p.

———1963, Geology of the Harper area, Malheur County, Oregon: Eugene, Oreg., University of Oregon master's thesis, 94 p.

Table 1. Whole-rock analyses, Harper quadrangle, Malheur County, Oregon[1]

Map letter	Laboratory no.	1/4	1/4	Sec.	T. (S.)	R. (E.)	U.T.M. coordinates	Elev. (ft)	Lithology	Map unit	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	LOI	Total	Cr	Rb	Sr	Y	Zr	Nb	Ba
											Oxides (wt. percent)												Trace elements (ppm)						
A	AYB-210	SE	SE	22	20	42	4850860N 455160E	2,880	Hypersthene basalt	Tdmv	54.6	16.7	0.95	7.57	0.18	8.17	4.99	1.20	3.29	0.28	1.77	99.9	131	134	518	<10	133	<10	655
B	AYB-206	NW	SE	24	20	42	4851100N 458140E	3,360	Olivine basalt	Tgyb	50.0	14.8	1.51	10.7	0.17	9.22	7.54	0.99	2.43	0.30	1.70	99.5	305	23	248	18	104	26	361
C	AYB-209	SE	NW	3	21	42	4846760N 454560E	3,560	Hypersthene basalt	Tdmv	54.4	16.7	0.95	7.67	0.18	8.17	4.48	1.36	3.14	0.28	2.16	99.7	130	71	549	<10	132	11	732
D	AYB-207	SE	SW	8	21	42	4844500N 451400E	3,200	Olivine basalt	Tdsb	49.6	15.9	1.76	11.5	0.19	9.10	5.63	0.88	3.09	0.59	1.70	100.1	119	<10	499	24	118	10	431
E	AYB-208	SW	NE	11	21	42	4845040N 456760E	4,000	Olivine basalt	Tgyb	50.0	15.6	1.46	10.3	0.17	9.95	6.92	0.90	2.48	0.29	0.77	99.0	220	19	249	27	98	25	540

[1] XRF analyses by XRAL.

Table 2. Trace-element analyses, altered rocks, Harper quadrangle, Malheur County, Oregon[1]

Map no.	Laboratory no.	1/4	1/4	Sec.	T. (S.)	R. (E.)	UTM coordinates	Elev. (ft)	Lithology	Map unit	Ag (ppm)	As (ppm)	Au (ppb)	Cu (ppm)	Hg (ppm)	Mo (ppm)	Pb (ppm)	Sb (ppm)	Tl (ppm)	Zn (ppm)	Bi (ppm)	Cd (ppm)	Ga (ppm)	Se (ppm)	Te (ppm)	Ba (ppm)	Co (ppm)	Cr (ppm)	Fe (wt %)	Li (ppm)	Mn (ppm)	Ni (ppm)	W (ppm)
1	AYB-132	SW	SW	34	19	42	4857260N 454780E	2,580	Ferruginous chalcedonic cherts	Tdsa	0.032	12.9	3	10.6	<0.10	3.43	2.50	0.310	<0.5	15.5	<0.25	0.114	3.21	<1.0	<0.5	65	2.9	235	0.98	103	194	5	<5
2	AYB-131	SE	NW	3	20	42	4856680N 454740E	2,700	Ferruginous chalcedonic cherts	Tdsa	0.026	44.8	2	8.37	<0.10	6.20	1.89	0.868	<0.5	8.43	<0.25	<0.10	1.90	<1.0	<0.5	111	1.8	269	0.88	108	203	<5	<5
3	AYB-130	SE	NW	3	20	42	4856380N 454460E	2,700	Ferruginous chalcedonic cherts	Tdsa	0.029	24.9	6	10.1	0.107	4.37	1.60	0.964	<0.5	9.75	<0.25	<0.10	1.61	<1.0	<0.5	129	2.6	370	0.93	106	148	6	<5
4	AYB-117	NE	SW	3	20	42	4856200N 454620E	2,620	Ferruginous chalcedonic cherts	Tdsa	0.034	67.4	2	9.52	<0.10	4.29	1.68	0.921	<0.5	8.09	<0.25	<0.10	2.23	<1.0	<0.5	59	1.7	216	0.88	113	280	11	<5
5	AYB-118	SE	SE	3	20	42	4855380N 455100E	2,740	Ferruginous chalcedonic cherts	Tdsa	0.048	10.4	33	14.6	<0.10	6.05	5.22	0.295	<0.5	32.1	<0.25	0.115	3.78	<1.0	<0.5	218	3.1	234	1.18	117	267	8	<5
6	AYB-129	NW	NW	11	20	42	4854920N 455600N	2,660	Ferruginous chalcedonic cherts	Tdsa	0.03	106	5	8.10	0.373	39.5	3.41	1.02	<0.5	12.5	<0.25	<0.10	2.71	<1.0	<0.5	454	4.4	196	1.24	86.2	142	9	5
7	AYB-136	SE	NW	17	20	42	4853120N 451320E	2,660	Iron-stained silicified tuff	Tds	0.033	47.9	<1	6.17	<0.10	2.27	15.0	1.05	<0.5	55.2	<0.25	0.416	4.85	<1.0	<0.5	374	6.5	97	1.35	45.8	151	12	<5
8	AYB-135	NW	NE	18	20	42	4853340N 450000E	2,620	Chalcedony vein	Tdsp	0.045	61.0	<1	12.4	<0.10	8.66	2.68	1.34	<0.5	9.30	<0.25	0.221	0.90	<1.0	<0.5	25	1.9	342	1.07	63.8	156	7	<5
9	AYB-128	SE	NE	27	20	42	4849240N 455440E	3,320	Iron-stained sandstone	Tbcs	0.04	8.15	<1	52.0	<0.10	2.28	2.70	<0.25	<0.5	69.2	<0.25	<0.10	10.0	<1.0	<0.5	284	27.8	221	8.90	10.8	370	83	<5
10	AYB-119	SE	SW	31	20	42	4847420N 449920E	3,080	Ferruginous chalcedonic cherts	Tdsa	0.035	4.62	1	13.0	<0.10	2.81	2.83	<0.25	<0.5	23.5	<0.25	0.123	3.61	<1.0	<0.5	48	2.6	208	0.94	97.3	272	7	<5
11	AYB-120	NE	SW	6	21	42	4846480N 449880E	3,000	Chalcedonic breccia	Tdsb	0.062	113	3	45.6	0.472	18.0	2.73	2.47	<0.5	29.7	<0.25	<0.10	5.03	0.995	<0.5	355	7.5	156	4.43	80.4	213	25	<5
12	AYB-121	SE	SE	6	21	42	4846020N 450640E	3,200	Chalcedonic breccia	Tdsb	0.05	165	3	24.3	0.339	11.1	2.67	1.76	<0.5	11.3	<0.25	<0.10	2.10	<1.0	<0.5	121	4.0	183	3.10	101	86	12	<5
13	AYB-122	NW	SW	5	21	42	4846340N 450900E	2,720	Ferruginous chalcedonic cherts	Tds	0.038	36.1	4	8.13	0.192	3.22	2.10	1.23	0.634	13.7	<0.25	<0.10	3.81	<1.0	<0.5	95	2.1	251	1.24	93.8	180	8	<5
14	AYB-123	SE	SW	3	21	42	4846020N 454580E	3,540	Silicified sandstone	Tbcs	0.04	8.18	2	5.17	<0.10	2.03	1.97	<0.25	<0.5	8.75	<0.25	<0.10	1.10	<1.0	<0.5	727	3.7	144	0.72	7.2	160	7	<5
15	AYB-133	SE	SW	3	21	42	4846200N 454560E	3,530	Manganese vein	Tbcs	0.057	788	<1	11.8	<0.10	81.7	35.7	4.85	5.40	110	0.482	1.64	2.76	<1.0	<0.5	5,440	25.8	17	25.2	5.6	208,000	42	40
16	AYB-124	SW	NW	8	21	42	4845480N 451080E	2,840	Iron-stained silicic breccia	Tdsb	0.049	105	3	10.8	0.541	3.38	4.54	2.36	<0.5	27.6	<0.25	0.121	4.73	<1.0	<0.5	140	4.8	66	1.41	69.1	168	7	<5
17	AYB-125	SW	NW	9	21	42	4845340N 452520E	3,080	Chalcedony vein	Tdsb	0.025	7.12	<1	4.92	<0.10	2.55	2.82	<0.25	<0.5	1.90	<0.25	<0.10	1.92	<1.0	<0.5	<5	0.5	254	0.87	28.4	96	6	<5
18	AYB-126	NW	NW	10	21	42	4845640N 454220E	3,500	Silicified arkosic sandstone	Tbcs	0.03	<1.0	4	5.27	<0.10	1.29	1.74	<0.25	<0.5	12.4	<0.25	<0.10	1.52	<1.0	<0.5	523	3.6	120	0.63	6.5	88	5	<5
19	AYB-127	NW	SE	11	21	42	4844680N 456920E	3,800	Opalite	Tbc	0.026	1.18	<1	4.99	<0.10	0.520	3.84	<0.25	<0.5	<1.0	<0.25	<0.10	<0.50	<1.0	<0.5	<5	<0.5	33	0.20	0.6	15	<4	<5

[1] Gold analyses by Bondar-Clegg; 14 elements by GSI; 8 elements by DOGAMI.

GEOLOGIC CROSS SECTIONS