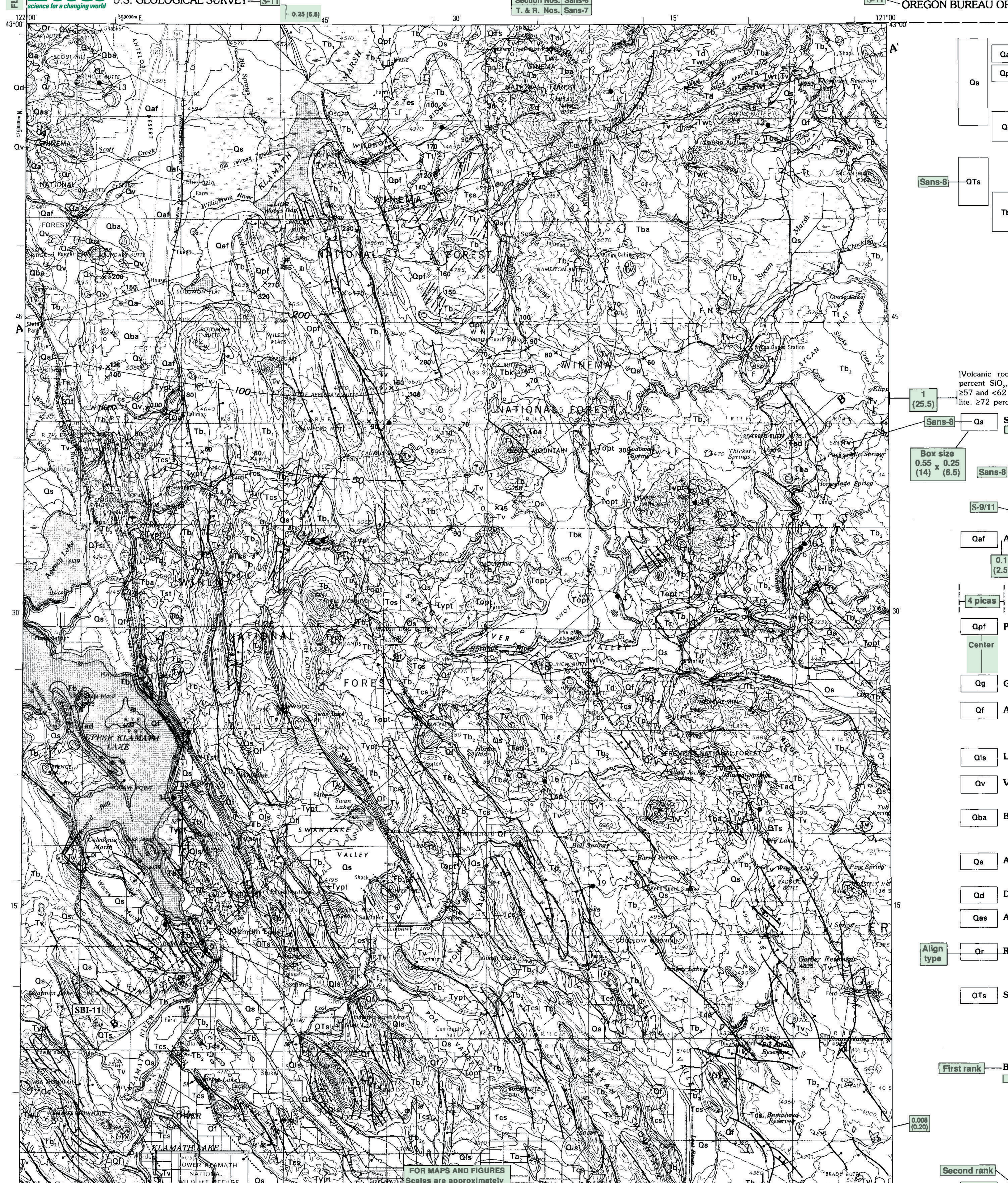
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
OREGON BUREAU OF MINES AND GEOLOGY

SCIENTIFIC INVESTIGATIONS MAP 2812
Version 1.0

If more than 1 line of type use 2 Ld (11/13)

ALIGN TO TOP OF MAP



Base from U.S. Geological Survey, Klamath Falls, 1955. Bathymetry in Upper Klamath Lake from Johnson and others (1985)
Universal Transverse Mercator projection

SCALE 1:250 000
CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
1981 MAGNETIC DECLINATION AT SOUTH EDGE OF SHEET VARIES FROM 17° TO 18° EAST
APPROXIMATE MEAN DECLINATION, 1992

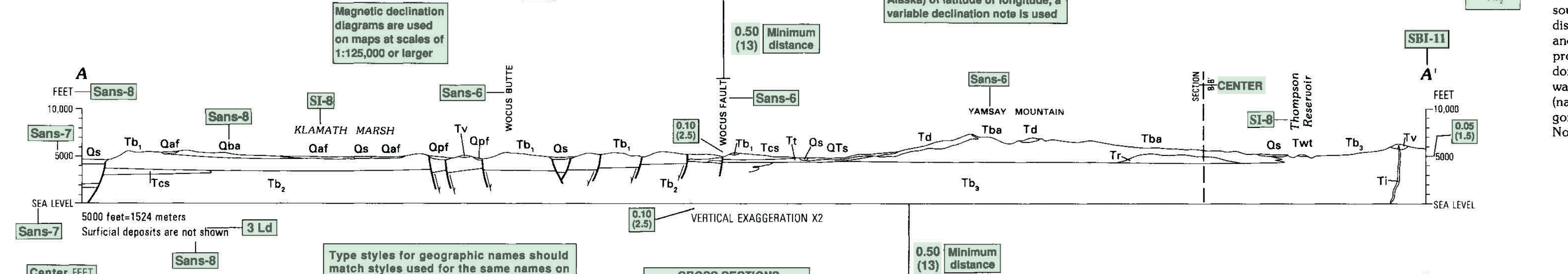
Magnetic declination diagrams are used on maps at scales of 1:125,000 or larger

If map covers more than 1° (30' in Alaska) of latitude or longitude, a variable declination note is used

Geology mapped by D.R. Sherrod, July–September 1983; July 1985. Potassium-argon geochronology by L.B.G. Pickthorn from samples collected July 1985
Edited by Sean Stone
Manuscript approved for publication April 27, 1990

MAP LOCATION

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1992



5000 feet=1524 meters
Surficial deposits are not shown
VERTICAL EXAGGERATION X2

0.50 (13) Minimum distance

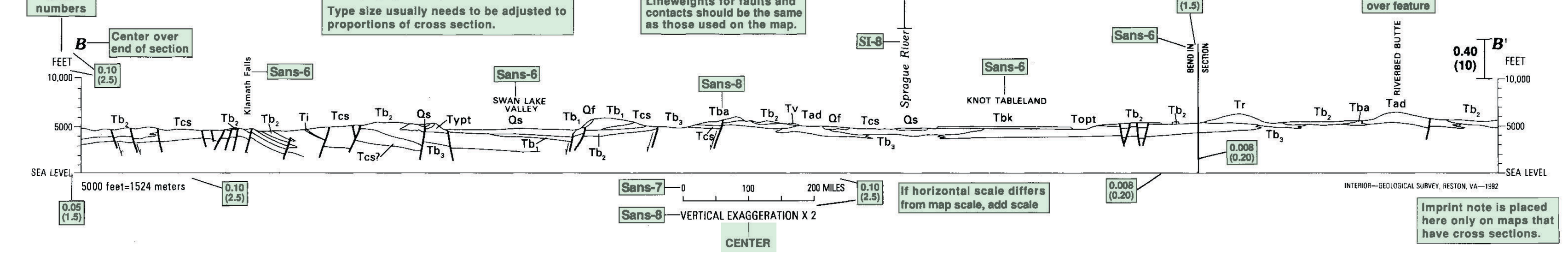
Type styles for geographic names should match styles used for the same names on the topographic map.
Type size usually needs to be adjusted to proportions of cross section.

CROSS SECTIONS
Linewidths for faults and contacts should be the same as those used on the map.

Center FEET over numbers

Center over end of section

Center name over feature



5000 feet=1524 meters
VERTICAL EXAGGERATION X 2
0 100 200 MILES

If horizontal scale differs from map scale, add scale

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1992

Imprint note is placed here only on maps that have cross sections.

CENTER

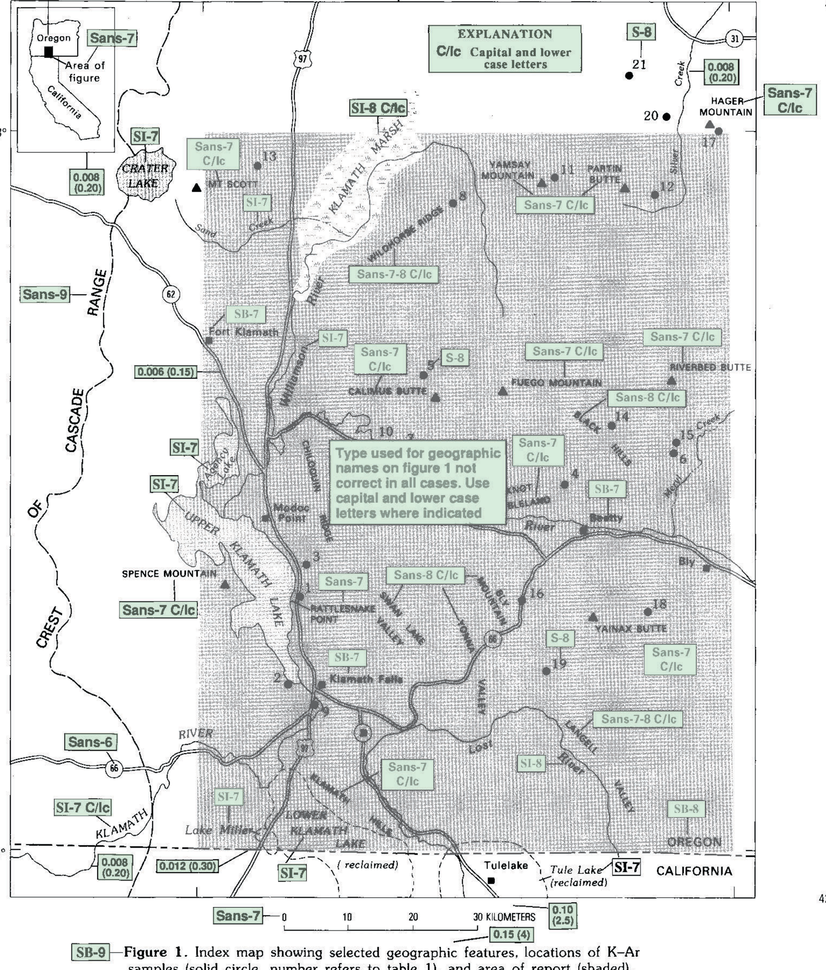


Figure 1. Index map showing selected geographic features, locations of K-Ar samples (solid circle, number refers to table 1), and area of report (shaded).

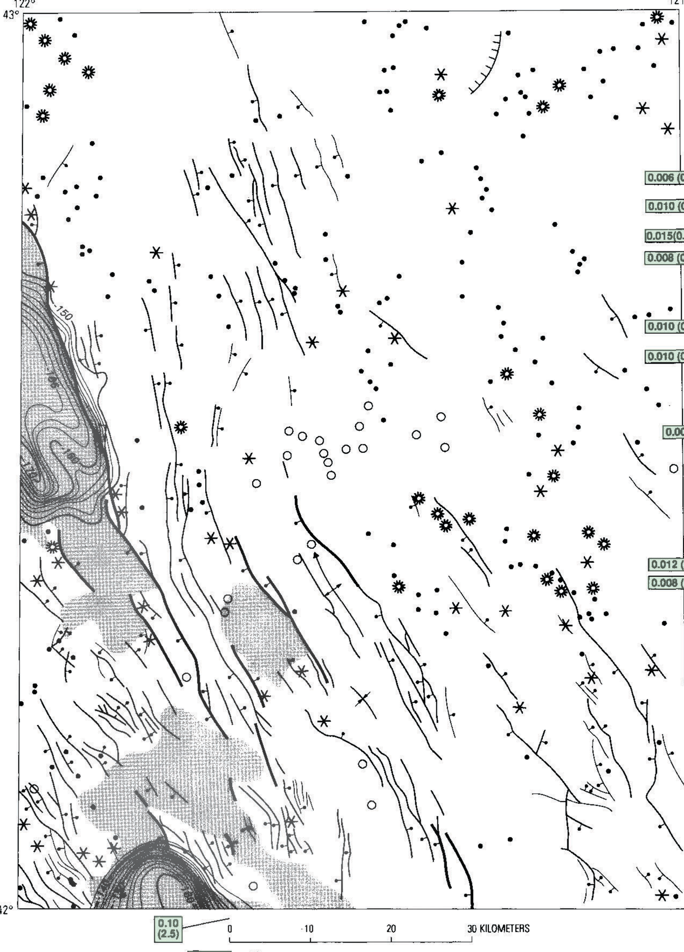


Figure 2. Tectonic sketch map.

EXPLANATION

Faults—Ball and bar on apparent downthrown side. Line width indicates characteristic offset along each fault segment

- Offset less than 30 m
- Offset between 30 and 100 m
- Offset greater than 100 m
- Caldera ring fault—Shown at Yamsay Mountain. Offset estimated between 30 and 100 m
- Anticline—Showing plunge
- Syncline

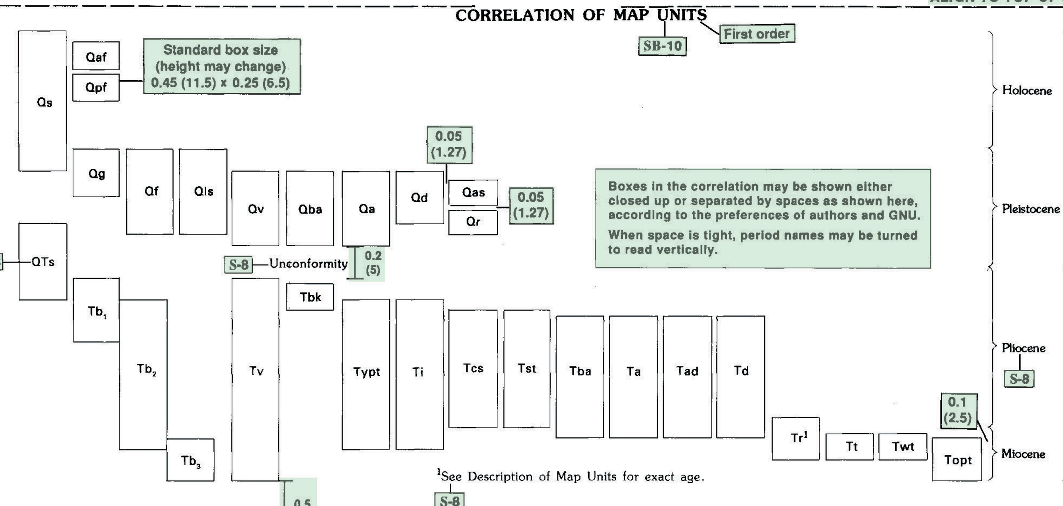
Vents
- Cinder cone
- Tuff cone (palagonite)
- Shield volcano
- Dome

Deep structural basin

Closely spaced Bouguer gravity contours whose steep gradients likely define deep parts of Klamath graben. Contour interval 2 mGal (from Couch and others, 1981)

Figure explanations follow the same format as the Description of Map Units except that bold type is not used.

CORRELATION OF MAP UNITS



[1]See Description of Map Units for exact age.

Standard box size (height may change) 0.45 (11.5) x 0.25 (6.5)

Boxes in the correlation may be shown either closed up or separated by spaces as shown here, according to the preferences of authors and GNU.
When space is tight, period names may be turned to read vertically.

DESCRIPTION OF MAP UNITS

[Volcanic rocks are named according to chemical classification, in terms of weight percent SiO_2, as follows: basalt, <52 percent; basaltic andesite, ≥52 and <57 percent; andesite, ≥57 and <62 percent; dacite, ≥62 and <67 percent; rhyodacite, ≥67 and <72 percent; rhyolite, ≥72 percent]

Box size 0.55 (14) x 0.25 (6.5)

Qs Surficial deposits (Holocene and Pleistocene)—Fine- to coarse-grained sediment deposited in channels, flood plains, marshes, and lakes. Includes playa deposits in closed depressions in Swan Lake and Yonna Valleys. Deposits in Klamath Marsh contain rounded pumiceous gravel derived from fluvial and lacustrine reworking of Holocene pumice-fall (Qpf) and ash-flow (Qaf) deposits; gravels form terraces at three distinct levels as high as 8 m above present wetlands along east side of Klamath Marsh. Pattern in northwest corner of map delineates Sand Creek fan bui... of U.S. Highwa... nd dunes on nor...

INDENT FOR DESCRIPTION OF MAP UNITS AND SYMBOLS*
First rank—"Left margin"
□Second rank—Indent 1 em space
□□Third rank—Indent 2 em spaces
□□□Fourth rank—Indent 3 em spaces
□□All overruns of all ranks—Indent 2 em spaces
*Digital style sheets (templates) to format Description of Map Units are available for some software. Please check with your BTR.

Qaf Ash-flow de... poorly sorted, ... h flows were e... uptions at Mou... of map area (W... sions as much a... may be partiall... corner of map... rce

Qpf Pumice-fall ... erupted about 6... azama. Mapped only where underlying units are buried over large areas; smaller discontinuous patches (not shown) blanket much of northern part of map area. Isopachs indicate thickness of deposit in centimeters

Qg Glacial deposits (Pleistocene)—Till in lateral and terminal moraines on east side of Mount Scott in High Cascades (fig. 1)

Qf Alluvial fan and talus deposits (Pleistocene)—Poorly to well-sorted sand and gravel in alluvial fans. Includes extensive talus sheets that mantle some fa... deposits on nort... igin

Leading indicated for Description of Map Units is minimum spacing. Leading may be increased to gain a little space to fit to the unit boxes or to fill out a column, as this one was in order to start the second column with a new unit. Be sure to increase the leading consistently, such as adding 3 lead after all first rank units.

Qls Landslide d... of steep slopes ... landform

Qv Vent depos... ider, agglutinate... or basalt, basaltic...

Qba Basaltic an... va flows and minor breccia erupted from vents in High Cascades. Short-dashed contact indicates separate lava flow erupted from cinder cone 10 km east of Fort Klamath

Qa Andesite (Pleistocene)—Slightly to moderately porphyritic two-pyroxene andesite lava flows in High Cascades. Some andesite contains minor amount of olivine

Qd Dacite (Pleistocene)—Moderately porphyritic hornblende-bearing lava flow or dom...

Qas Andesite o... itic two-pyroxen... tely 0.42 Ma (Bacon, 1983, addendum to p. 63)

Use the same type style for unit symbols in the Description of Map Units and text as is used for unit symbols on the map.

Align type

Qr Rhyolite and rhyodacite (Pleistocene)—Light-gray to white, aphyric to porphyritic flow-banded rhyolite and rhyodacite forming large domes. Potassium-argon ages between 0.7 and 0.6 Ma (Bacon, 1983, addendum to p. 63)

QTs Sedimentary deposits and rocks (Pleistocene and Pliocene)—Unconsolidated sand and gravel, poorly to moderately indurated sandstone and conglomerate, and diatomite exposed mainly in Lower Klamath Lake basin, east of Agency Lake, and on west slope of Yamsay Mountain. Includes strata that unconformably overlie the Miocene and Pliocene continental sedimentary rocks (Tcs) as well as strata of uncertain relation to that unit

First rank

Basalt of Basin and Range (Pliocene and Miocene)—Aphyric to porphyritic lava flows and minor breccia; chiefly intergranular to subophitic and locally diktytaxitic basalt and lesser amount of intergranular basaltic andesite. Contains phenocrysts (1–2 mm long) of olivine and greater or lesser amounts of plagioclase and, locally, clinopyroxene. Locally includes interbedded, poorly exposed, poorly indurated sedimentary and pyroclastic volcanic rocks, which are commonly buried by basalt float. Units Tb_1, Tb_2, and Tb_3 (basalt flows) are separated on basis of degree of alteration and tectonic deformation, stratigraphic relations with sedimentary units, and geomorphic criteria such as nesting of flows; however, isotopic ages of the different units overlap when compared regionally. Divided into:

Second rank

Tb_1 Unit 1 (Pliocene)—Lava flows extending from Wildhorse Ridge south through Calimus Butte area and southwest through Chiloquin Ridge area. Unconformably overlies Miocene and Pliocene unit Tb_2 near Sprague River but conformably overlies it at most other locales. Potassium-argon ages from Wildhorse Ridge and Calimus Butte areas are 3.68±0.08 and 3.44±0.13 Ma, respectively; whereas ages from southeast of Modoc Point are 2.80±0.06 and 1.9±0.5 Ma (table 1, map Nos. 1, 3, 5, and 8). The latter two ages are from about the same stratigraphic position, and the preferred age there is 2.80 Ma (Pickthorn and Sherrod, in press)

Overrun lines

Tb_2 Unit 2 (Pliocene and Miocene)—Lava flows throughout southwestern, south-central, and northeastern parts of map area. Lithologically indistinguishable from unit Tb_1 and is separated chiefly on geomorphic and structural criteria; overall, the unit probably contains a greater proportion of diktytaxitic lava compared to lava in unit Tb_1 which is dominantly intergranular in texture. Part of unit in south-central area was included in the basalt of Devils Garden by McKee and others (1983) (named for Devils Garden in Modoc County, Calif.). Potassium-argon ages in map area range from 6.88 to 3.61 Ma (table 1, map Nos. 6, 10, 18, and 19); age is late Miocene and Pliocene

Tb_3 Unit 3 (Miocene)—Lava flows in east half of map area. Flows commonly show extensive alteration of groundmass glass to greenish smectite. Potassium-argon age of 5.78±0.12 Ma from lava flow east of Black Hills in east-central part of map area (table 1, map No. 15); unit is in part older than rhyolite domes (Tr). Age is late Miocene; correlative with the regionally defined basalt of Devils Garden of McKee and others (1983)

Tv Vent deposits (Pliocene and Miocene)—Cones and irregular piles of cinder, agglutinate, and minor lava flows and intrusions. Forms vents for the basalt of Basin and Range (Tb_1, Tb_2, and Tb_3)

Tbk Basalt of Knot Tableland (Pliocene)—Diktytaxitic olivine basalt lava flow or flows that form prominent bench north of Sprague River in central part of map area. Unit is lithologically similar to the adjacent basalt of Basin and Range (Tb_1, Tb_2, and Tb_3) but is younger on basis of its topographic inversion—it fills a broad surface that is cut, in part, into unit Tb_1—and lack of deformation. Potassium-argon age of 3.0±0.9 Ma (table 1, map No. 4)

Typt Younger palagonite tuff (Pliocene and Miocene)—Poorly bedded deposits of palagonitized basaltic ash and lapilli and minor interbedded lava flows. Forms some of the vents that erupted a part (Tb_2) of the basalt of Basin and Range (other vents in unit Tv). Commonly forms discrete, circular tuff cones centered around individual vents. Elsewhere, vent deposits have coalesced to form large masses of palagonite in which individual eruptive centers are inferred from circular physiographic features and outwardly dipping beds; outline of individual centers shown by short-dashed line. Unit is interbedded with and overlies the continental sedimentary rocks (Tcs). Partial equivalent of the herein-abandoned Yonna Formation

Ti Intrusions (Pliocene and Miocene)—Exposed in three areas: (1) plugs of very fine to fine-grained basalt and basaltic andesite that intrude vent deposits (Tv) at Yainax Butte and Fuego Mountain, (2) gabbro sill northeast of Klamath Falls, and (3) basalt sills or auto-invasive flows southwest of Klamath Falls

Tcs Continental sedimentary rocks (Pliocene and Miocene)—Thinly bedded to very thick bedded ashy diatomite; thin- to medium-bedded sandstone, siltstone, and laminated mudstone; conglomerate; and minor tuff and basalt lava flows. Overlies welded tuff and tuff units (Twt and Tt) in northeastern and east-central part of map area but is interbedded with oldest unit (Tb_3) of the basalt of Basin and Range in southeastern part. Partial equivalent of the herein-abandoned Yonna Formation

Tst Tuff and sandstone (Pliocene and Miocene)—Pale-gray to medium-gray lithic tuff and weakly lithified tuffaceous sandstone, some of which was probably deposited as lahars. Includes very poorly exposed rocks that underlie youngest unit (Tb_1) of the basalt of Basin and Range in Modoc Point area and laharic sandstone exposed beneath basalt (Tb_2) in fault scarps southeast of Klamath Falls. Probably interbedded with unit Tb_2 regionally

Tba Basaltic andesite and andesite (Pliocene and Miocene)—Aphyric to porphyritic, intergranular to pilotaxitic lava flows and minor breccia. Near Yamsay Mountain, unit is basaltic andesite, where SiO_2 content is mostly in the range of 53 to 58 percent (29 analyses; Hering, 1981). Include... ountain, north o... d Butte. Probabl...

Ta Andesite (P... y Mountain (fo... d a thick flow in...

Tad Andesite a... andesite and hor... ow near Summit... geneous, varying... andesite in the r... utheast

Td Dacite (Pli... hes. Includes d... nt SiO_2; Hering,... 79 Ma (table 1,... (central part of...

Tr Rhyolite a... to moderately... ophyric. Potassium-argon ages range from ... Ma (table 1, map Nos. 12, 14, 16, and 17); age of unit is late Miocene and Pliocene(?). Crops out in east-central and northeastern part of map area

CONVERTING MEASUREMENTS

If you have:	Multiply by:	To get:
Points	.3528	Millimeters
Points	.0833	Picas
Points	.0139	Inches
Millimeters	2.835	Points
Millimeters	.236	Picas
Millimeters	.03937	Inches
Picas	12	Points
Picas	4.2333	Millimeters
Picas	.1667	Inches
Inches	72	Points
Inches	25.4	Millimeters
Inches	6	Picas

Tt Tuff and lapilli tuff (Miocene)—Lithic-bearing and pumiceous lapilli tuff, largely of ash-flow or hot-avalanche origin. Also includes thin- to medium-bedded fine-grained tuff, coarse pumicite (air fall), and very thick to thin-bedded pebbly sandstone that was probably deposited as lahars. Unit chiefly overlies oldest unit (Tb_3) of the basalt of Basin and Range but is also interbedded with it along Meryl Creek (north of Bly, east-central edge of map), at Whitmore Reservoir (1 km west of Bly), and in Langell Valley (southeastern part of map area). Previously included in the herein-abandoned Yonna Formation

Twt Welded tuff (Miocene)—Densely welded to locally unwelded dacitic or rhyodacitic ash-flow tuff. Unit consists of two separate subunits: the Silver Creek Welded Tuff of Hering (1981, 1982) in northeast corner of map area and welded tuff exposed on and around K Davis Hill (4 km west of Beatty). The Silver Creek Welded Tuff has K-Ar ages of 7.36±1.58 and 6.95±1.13 Ma (table 1, map N 20 and 21)

Topt Older palagonite tuff (Miocene)—Poorly bedded deposits of palagonitized basaltic ash and lapilli. Forms some vents for oldest unit (Tb_3) of the basalt of Basin and Range (other vents in unit Tv). Individual eruptive centers within large masses of palagonite are inferred from circular physiographic features and outwardly dipping beds; outline of individual centers shown by short-dashed line. Underlies rhyolite dome (Tr) in Black Hills, which has K-Ar age of 5.52±0.55 Ma (table 1, map No.14). Partial equivalent of the herein-abandoned Yonna Formation

Geology line symbols on the map and those in the explanation should be the same

Contact—Approximately located. Short dash indicates separate lava flow within basaltic andesite (Qba) 10 km east of Fort Klamath and outline of individual eruptive center in large mass of palagonite tuff (Topt and Typt)

Fault—Dashed where approximately located or inferred; dotted where concealed. Showing dip; ball and bar on downthrown side; half arrows indicate direction of relative movement in cross sections

Fault having probable Holocene displacement—Dashed where approximately located or inferred; dotted where concealed. Showing dip; ball and bar on downthrown side. Shown only in Klamath basin. See section entitled "Structure" for discussion of age criteria

Caldera ring fault—Shown only at Yamsay Mountain

Lineament—Interpreted from aerial photographs; shown only in north-central part of map

Anticline—Dotted where concealed. Showing crestline and direction of plunge

Syncline

Bathymetric contours—In Upper Klamath Lake; datum is mean lake level, contour interval is 10 ft (from Johnson and others, 1985)

Ridgecrest of sand dunes—Shown only within unit Qs in southwest corner of map

Thickness of Holocene pumice-fall deposits (Qpf)—Thickness in centimeters; shown in northwest corner of map

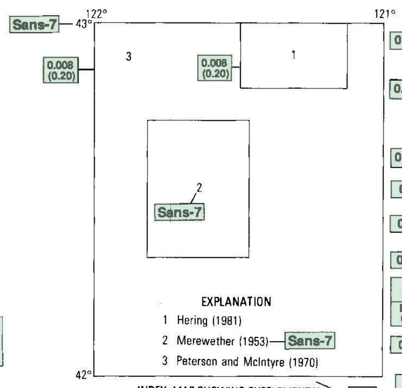
Isopach

Measurement locality

Strike and dip of clastic strata—Parentheses indicate photogeologic interpretation of dip in basalt of unit Tb_3

Potassium-argon sample locality—Number refers to table 1 and figure 1

Column width 3" - 5"



INDEX MAP SHOWING SUPPLEMENTAL SOURCES OF GEOLOGIC MAPPING

Table 1. *Summary of K-Ar ages in map area and vicinity*

Map No.	Sample No.	Location: Latitude (N.)	Location: Longitude (W.)	General geographic local and map unit	Rock type	Material dated	Calculated age (Ma)[1]	Reference
1	KFE-11	42°21.0'	121°49.0'	Southeast of Modoc Point; Tb_1	Basalt	Whole rock	1.9±0.5	M. O'Brien and S. Benson, in Fiebelkorn and others (1983)[2].
2	KFW-6	42°14.0' (location not exact)	121°50.0'	South of Upper Klamath Lake; map unit uncertain	Andesite, tuff	Whole rock	2.3±0.2	Do.
3	S5-1	42°23.8'	121°48.6'	Southeast of Modoc Point; Tb_1	Basalt	Whole rock	2.80±0.06	Pickthorn and Sherrod (in press).
4	S5-6	42°30.9'	121°18.9'	Knot Tableland; Tbk	Basalt	Whole rock	3.0±0.9	Do.
5	S5-3	42°39.7'	121°34.8'	North of Calimus Butte; Tb_1	Basalt	Whole rock	3.44±0.13	Do.
6	S5-8	42°33.3'	121°06.1'	East of Black Hills; Tb_2	Basalt	Whole rock	3.61±0.14	Do.
7	S5-4	42°33.6'	121°39.3'	S'Ocholis Canyon; Tcs	Pumiceous lahar	Plagioclase	3.62±0.12	Do.
8	S5-2	42°54.8'	121°31.2'	Wildhorse Ridge; Tb_1	Basalt	Whole rock	3.68±0.08	Do.
9	S5-12	42°12.6'	121°47.2'	Klamath Falls; lava flow in Tcs	Basalt	Plagioclase	4.47±0.28	Do.
10	S5-5	42°33.6'	121°40.0'	S'Ocholis Canyon; Tb_2	Basalt	Plagioclase	4.56±0.57	Do.
11	M4-131	42°56.6'	121°19.5'	Yamsay Mountain; Td	Dacite	Whole rock	4.79±0.17	MacLeod and others (1976); McKee and others (1976); Fiebelkorn and others (1983).
12	M4-130	42°54.9'	121°08.5'	Partin Butte; Tr	Rhyolite	Whole rock	5.15±0.21	Do.
13	M5-45	42°56.9'	121°54.8'	East of Crater Lake; Qr	Rhyodacite	Plagioclase	[3]5.5±0.5	Bacon (1983), E.H. McKee, (written commun., 1986).
14	M3-106	42°35.6'	121°13.4'	Black Hills; Tr	Rhyolite	Plagioclase	5.52±0.5	MacLeod and others (1976), McKee and others (1976); Fiebelkorn and others (1983).
15	S5-7	42°33.4'	121°05.9'	East of Black Hills; Tb_3	Basalt	Plagioclase	5.78±0.12	Pickthorn and Sherrod (in press).
16	M5-2	42°21.1'	121°23.9'	Bly Mountain; Tr	Rhyolite	Plagioclase	5.8±4	Fiebelkorn and others (1983).
17[4]	M3-61	43°00.6'	121°01.2'	Hager Mountain; Tr	Rhyolite	Obsidian	6.06±0.09	MacLeod and others (1976); McKee and others (1976); Fiebelkorn and others (1983).
18	S5-9	42°20.0'	121°09.1'	East of Yainax Butte; Tb_2	Basalt	Whole rock	6.16±0.13	Pickthorn and Sherrod (in press).
19	S5-10	42°16.0'	121°20.7'	Southwest of Yainax Butte; Tb_2	Basalt	Plagioclase	6.88±0.60	Do.
20[4]	M4-74	43°01.6'	121°06.9'	West of Silver Creek; Twt	Silicic ash-flow tuff	Plagioclase	6.95±1.13	McKee and others (1976); Fiebelkorn and others (1983).
21[4]	M4-73	43°05.2'	121°11.2'	West of Silver Creek; Twt	Silicic ash-flow tuff	Plagioclase	7.36±1.58	Do.

[1] K-Ar ages were calculated from data in references using the constants for the radioactive decay and abundance of ^{40}K recommended by the International Union of Geological Sciences Subcommission on Geochronology (Steiger and Jäger, 1977). These constants are: $\lambda_\varepsilon = 0.580 \times 10^{-10} yr^{-1}$, $\lambda_\beta = 4.962 \times 10^{-10} yr^{-1}$, and $^{40}K/K_{total} = 1.167 \times 10^{-4}$ mol/mol.
[2] Using a preprint, Fiebelkorn and others (1983) published the data and referenced it to Lawrence Berkeley Laboratory Report No. 11240 (1981), which never was published.
[3] Age of 5.5 Ma is incorrect. Subsequent determinations from domes in the same area are 0.7 to 0.6 Ma (Bacon, 1983, addendum to p. 63).
[4] Sample locality is outside boundary of geologic map. See figure 1 for location.

GEOLOGIC SUMMARY

STRATIGRAPHY

The west half of the Klamath Falls 1° by 2° quadrangle encompasses about 9,000 km², most of which is in the Basin and Range province of south-central Oregon (fig. 1). The map also includes a small part of the Cascade Range province along the eastern flank of the range. Bedrock in the map area is mostly upper Miocene and Pliocene basalt and basaltic andesite, but the rocks vary in composition from basalt to rhyolite. Continental fluviolacustrine strata locally interfinger with the volcanic rocks. In the north half of the map area, the entire sequence becomes younger to the west, culminating with Pleistocene and Holocene rocks and deposits in the Cascade Range. In the south half, structural complications and inadequate isotopic dating preclude specifying the overall age pattern of the sequence.

Basalt and minor basaltic andesite lava flows—the basalt of Basin and Range (Tb_1, Tb_2, and Tb_3)—predominate in all but the northwestern part of the map area. The flows were erupted from vents associated with (1) scattered shield volcanoes ranging from 2 to 4 km in diameter and as much as 500 m high, (2) tuff cones that formed where the vents erupted into lakes or through a zone of abundant ground water, and (3) numerous ci... ng faults. These lava flows were ... (Wells and Peck, 1961; Peterson ... range from 6.88 to 1.9 Ma, indicating the flows are mostly late Miocene and Pliocene (table 1).

Digital style sheets (templates) to format text are available for some software. Please check with your BTR.

Basaltic andesite (Tba) dominates at Yamsay Mountain, a broad volcano about 25 km long, 20 km wide, and about 1,000 m high, whose summit area includes a buried caldera and an arcuate segment of a ring fault (Hering, 1981). Fuego Mountain, 30 km to the south-southwest, is also built chiefly of basaltic andesite. Other areas mapped as basaltic andesite are scattered throughout the map area. The basaltic andesite, which is undated by radiometric methods, is late Miocene and Pliocene in age on the basis of its interfingering relations with adjacent dated volcanic rocks. Pleistocene basaltic andesite (Qba) is exposed adjacent to Mount Mazama (fig. 1, Crater Lake caldera) in the Cascade Range.

Pliocene andesite and dacite (Ta, Tad, and Td) include lava flows and domes on Yamsay Mountain (Hering, 1981), as well as previously unmapped andesite and dacite at Riverbed Butte, Bly Mountain, on the east flank of Chiloquin Ridge, in the center of Eagle Ridge (west of Upper Klamath Lake), and near Fort Klamath (fig. 1). All are slightly to moderately porphyritic and resemble calc-alkaline rocks of the Cascade Range; chemical analyses are available only for the Yamsay Mountain lava (Hering, 1981). Quaternary andesite and dacite (Qas, Qa, and Qd) are exposed in the Cascade Range on the east flank of Mount Mazama (northwest corner of map area).

The oldest silicic rocks are rhyodacite to rhyolite domes (Tr) and small-volume pyroclastic flows (Twt and Tt) on the east and west sides of Yamsay Mountain, at the Black Hills and Ferguson and Medicine Mountains, and near Bly Mountain. Extensive sheets of ash-flow tuff are lacking in this part of the Basin and Range province. Part of the Hager Mountain dome (fig. 1), which erupted mainly north of the map area (MacLeod and others, 1976), is exposed in the northeast corner of the map area. The domes have K-Ar ages ranging from 6.06±0.09 to 5.15±0.21 Ma (table 1), whereas the pyroclastic flows at Yamsay Mountain (Silver Creek Welded Tuff of Hering, 1981 and 1982) have K-Ar ages of 7.36±1.58 and 6.95±1.13 Ma. The only other silicic domes within the map area are in the Cascade Range near Mount Mazama and are middle Pleistocene in age; their radiometric ages range from 0.7 to 0.6 Ma (Bacon, 1983, addendum to p. 63). A 5.5-Ma age (table 1, map No. 13) obtained earlier by E.H. McKee (in Bacon, 1983) is now considered incorrect.

Continental sedimentary strata (Tcs)—diatomite, mudstone, sandstone, and conglomerate—were deposited during late Miocene and Pliocene time in a series of freshwater lakes and deltas in the central and southern parts of the map area (Newcomb, 1958). Pliocene diatomite also crops out west of the map area in the Cascade Range (Smith and others, 1982). Many of these rocks were previously assigned to the Yonna Formation by Newcomb (1958), the type section of which contains sedimentary (fluviolacustrine) strata overlain by basaltic lapilli tuff (palagonitic tuff cones). As originally mapped, the Yonna Formation also included large areas of primary volcaniclastic rocks such as silicic tuff (welded and unwelded pyroclastic flows) and lahar deposits. Because our mapping distinguishes volcanogenic deposits from continental sedimentary rocks, we here abandon the Yonna Formation, reassigning its rocks to several unnamed units (that is, Typt, Tcs, Tt, and Topt).

The unit of continental sedimentary rocks (Tcs) is latest late Miocene and Pliocene in age, on the basis of K-Ar ages (Pickthorn and Sherrod, in press). Near Beatty the continental sedimentary rocks are underlain by basalt lava flows, silicic domes, and pyroclastic flows that range in age from 6.88 to 5.52 Ma; the unit is overlain by 3.61-Ma basalt (table 1). Near Klamath Falls, a lava flow that has an age of 4.47±0.28 Ma is interbedded with the continental sedimentary rocks (table 1, map No. 9). Near Wildhorse Ridge (fig. 1), conglomerate and sandstone (Tcs) are overlain by 3.68-Ma basalt lava (table 1, map No. 8). Thus, most exposures of the unit of continental sedimentary rocks are probably between about 5.5 Ma and 3.6 Ma in age. This age assignment also applies to the lower part of the Yonna Formation, which on the basis of mammalian and fish fossils was considered Pliocene in age (broadly 12 to 2 Ma for the time scale then in use) (Newcomb, 1958).

Sedimentation in the map area was greatly restricted during Pleistocene time, probably because the Klamath River had established its present-day course through the Cascade Range by late Pliocene time and integrated previously separate basins. Pleistocene sedimentary deposits include alluvium along valley floors, a few alluvial fans and talus cones, and graben-filling fluviolacustrine beds in the basins of Upper and Lower Klamath Lakes and the closed depression of Swan Lake Valley. Even today, lacustrine deposits, including diatomaceous strata, continue to form in Upper Klamath Lake, one of the largest freshwater lakes in the western United States. Lower Klamath Lake is now mostly agricultural land, reclaimed since 1940 by the U.S. Bureau of Reclamation.

STRUCTURE

Faults

North- to northwest-striking normal faults are the predominant structural feature in the west half of the Klamath Falls 1° by 2° quadrangle. Displacement is mostly less than 100 m in the central and eastern parts of the map area but increases to as much as 2 km on faults in the Klamath basin near the southwest corner of the map area. Exposed fault surfaces dip 50° to 60°, and most slickensides and mullions plunge directly downdip, consistent with normal slip.

The Klamath basin is a composite graben that forms the westernmost structural trough of the Basin and Range physiographic province. Extensional strain across the basin is probably less than 15 percent, although the estimates are necessarily conjectural because of uncertain fault geometry. Graben-bounding faults at the present-day level of erosion are broadly planar. East of the basin, decreasing number of faults and diminished displacement along them indicate greatly diminished strain (fig. 2).

In the southern part of the basin, a simple graben largely coincident with the original extent of Lower Klamath Lake coincides with a 20-mGal gravity depression (fig. 2; Sammel and Peterson, 1976; Couch and others, 1981). The gravity anomaly suggests that sediment as thick as 2 km (Sammel and Peterson, 1976) fills the graben. At Klamath Falls the graben shoals, and Quaternary sediment laps against upper Miocene and lower Pliocene lava flows and sedimentary rocks. In the northern part of the basin, Upper Klamath Lake floods, in part, a graben that reaches nearly to Crater Lake. The eastern escarpment of this graben has 450 m of structural relief in the Klamath Falls area. Although topographic relief diminishes northward, structural relief probably persists. Gravity data indicate that 0.4 to 1.2 km of sedimentary deposits (density contrast ranging from 1.0 to 0.3 gm/cm³, respectively) probably fill the basin north of Modoc Point (Veen, 1982).

The inception of Klamath graben faulting is poorly constrained. The Sprague River, which drains into the graben's north end, was probably established along its present-day route by 3 Ma. At about the same time, the basalt of Knot Tableland flowed south and west into the Sprague River valley. Presumably, downcutting at the mouth of the Sprague was controlled by both the nascent Klamath graben and the headward erosion of the Klamath River through the Cascade Range and into the upper Klamath basin.

Most of the Klamath graben is Pleistocene in age, however, and some faults have been active in Holocene time. The 400 m of topographic structural relief near Klamath Falls developed after eruption of lava flows as young as 2.80 to 1.9 Ma, which is the age of rocks capping the escarpment near Modoc Point (table 1, map N 1 and 3). Escarpments throughout the basin are commonly straight, steep, and relatively uneroded. Talus deposits exposed in the hanging wall of several youthful escarpments are themselves faulted and not merely scree buttressing against an exposed fault plane, as seen in excellent exposures where these deposits are quarried (for example, in Klamath Hills east of Lower Klamath Lake; near U.S. Highway 97 west of Lower Klamath Lake; and along U.S. Highway 97 east of Upper Klamath Lake). Upper Klamath Lake, which averages between 3 and 6 m deep, lacks alluvial fans along its escarpment-bounded margins, a condition most easily explained by continued Holocene subsidence. An elongate bathymetric trough ranging from 6 to 12 m deep and coincident with a fault on the west side of the lake is probably at least partly younger than basin-filling ash flows erupted from Mount Mazama about 6,845 ¹⁴C yr B.P. (age from Bacon, 1983), on the assumption that pyroclastic debris would have choked and buried the narrow trough.

Northeast-striking faults are rare. Many closely spaced, short northeast-trending lineaments of uncertain origin are shown west of Yamsay Mountain (north-central part of map), in an area blanketed by Holocene pumice-fall deposits (Qpf) and underlain by relatively easily eroded sedimentary and pyroclastic rocks (Tcs and Tt).

Folds

Two folds shown in Yonna Valley are inferred from the outcrop pattern of map units and dip of bedding. They may result from extensional processes such as reverse and normal drag flexures (for example, Hamblin, 1965) or perhaps from localized contraction due to differential subsidence. The interpretation of folding could be incorrect, and the oppositely dipping beds may indicate differentially tilted fault blocks. Exposures in Yonna Valley are too poor to resolve this uncertainty.

Folded near-vent deposits are exposed in a roadcut along U.S. Highway 97 at Rattlesnake Point on the east side of Upper Klamath Lake (fig. 1), where a northwest-striking fault displaces the deposits against an adjacent block to the west. The fold, which cannot be traced beyond the outcrop and is not shown on the map, is an asymmetric anticline that may have resulted from drag created during oblique slip. No slickensides are exposed on the fault plane.

REFERENCES CITED

Bacon, C.R., 1983, Eruptive history of Mount Mazama and Crater Lake caldera, Cascade Range, U.S.A.: Journal of Volcanology and Geothermal Research, v. 18, p. 57–115.
Couch, R.W., Pitts, G.S., Veen, C.A., and Gemperle, Michael, 1981, Free-air gravity anomaly map and complete Bouguer gravity anomaly map, Cascade Mountain Range, southern Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS–16, scale 1:250,000.
Fiebelkorn, R.B., Walker, G.W., MacLeod, N.S., McKee, E.H., and Smith, J.G., 1983, Index to K-Ar age determinations for the state of Oregon: Isochron/West, no. 37, p. 2–60.
Hamblin, W.K., 1965, Origin of reverse drag on the downthrown side of normal faults: Geological Society of America Bulletin, v. 76, no. 10, p. 1145–1164.
Hering, C.W., 1981, Geology and petrology of the Yamsay Mountain complex, south-central Oregon: A study of bimodal volcanism: Eugene, University of Oregon, Ph.D. dissertation, 194 p.
———1982, Geology and petrology of the Yamsay Mountain complex, south-central Oregon: A study of bimodal volcanism: Dissertation Abstracts International, v. 42, no. 11, p. 4332-B.
Johnson, D.M., Petersen, R.R., Lycan, D.R., Sweet, J.W., Neuhaus, M.E., and Schaedel, A.L., 1985, Atlas of Oregon Lakes: Corvallis, Oregon State University Press, 317 p.
MacLeod, N.S., Walker, G.W., and McKee, E.H., 1976, Geothermal significance of eastward increase in age of upper Cenozoic rhyolitic domes in southeastern Oregon, in Second United Nations Symposium on the Development and Use of Geothermal Resource, San Francisco, Calif., May 20–29, 1975, Proceedings, v. 1: Washington D.C., U.S. Government Printing Office, p. 465–474.
McKee, E.H., MacLeod, N.S., and Walker, G.W., 1976, Potassium-argon ages of Late Cenozoic silicic volcanic rocks, southeastern Oregon: Isochron/West, no. 15, p. 37–41.
McKee, E.H., Duffield, W.A., and Stern, R.J., 1983, Late Miocene and early Pliocene basaltic rocks and their implications for crustal structure, northeastern California and south-central Oregon: Geological Society of America Bulletin, v. 94, no. 2, p. 292–304.
Merewether, E.A., 1953, The geology of the lower Sprague River area, Klamath County, Oregon: Eugene, University of Oregon, M.S. thesis, 62 p.
Newcomb, R.C., 1958, Yonna Formation of the Klamath River Basin, Oregon: Northwest Science, v. 32, no. 2, p. 41–48.
Peterson, N.V., and McIntyre, J.R., 1970, The reconnaissance geology and mineral resources of eastern Klamath County and western Lake County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 66, 70 p.
Pickthorn, L.B.G., and Sherrod, D.R., in press, Potassium-argon ages from Klamath Falls area, south-central Oregon: Isochron/West.
Sammel, E.A., and Peterson, D.L., 1976, Hydrologic reconnaissance of the geothermal area near Klamath Falls, Oregon, with a preliminary interpretation of geophysical data: U.S. Geological Survey Water Resources Investigation Open-File Report WRI 76–127, 129 p.
Smith, J.G., Page, N.J, Johnson, M.G., Moring, B.C., and Gray, Floyd, 1982, Preliminary geologic map of the Medford 1° by 2° quadrangle, Oregon and California: U.S. Geological Survey Open-File Report 82–955, scale 1:250,000.
Steiger, R.H., and Jäger, E., 1977, Subcommission on geochronology: Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, no. 3, p. 359–362.
Veen, C.A., 1982, Gravity anomalies and their structural implications for the southern Oregon Cascade Mountains and adjoining Basin and Range province: Eugene, University of Oregon, M.S. thesis, 86 p.
Wells, F.G., and Peck, D.L., 1961, Geologic map of Oregon west of the 121st meridian: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–325, scale 1:500,000.
Williams, Howel, 1942, The geology of Crater Lake National Park, Oregon, with a reconnaissance of the Cascade Range southward to Mount Shasta: Carnegie Institute of Washington Publication 540, 162 p.

Column width 3" - 5"

GEOLOGIC MAP OF THE WEST HALF OF THE KLAMATH FALLS 1° × 2° QUADRANGLE, SOUTH-CENTRAL OREGON

By
David R. Sherrod and Leda Beth G. Pickthorn
1992

Printed on recycled paper — This symbol on printed maps only

Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Government

For sale by U.S. Geological Survey Information Services Box 25286, Federal Center, Denver, CO 80225
1-888-ASK-USGS
GIS files and a PDF file for this map are available at http://pubs.usgs.gov/map/2004/2812
ISBN 0-607-88986-1

Bar code on printed maps only

Notes on printed maps; check with CPG for specific URL.

Add when applicable

If map on demand, use alternative form of this note; check with CPG for specific URL

Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Government

This map was produced on request, directly from digital files, on an electronic plotter

For sale by U.S. Geological Survey Information Services, Box 25286, Federal Center, Denver, CO 80225; 1-888-ASK-USGS
GIS files and a PDF file are available online at http://pubs.usgs.gov/map/2004/2812

SCIENTIFIC INVESTIGATIONS MAP 2812 — S-12/15
Version 1.0 — S-11/16
IF PAMPHLET ACCOMPANIES MAP..... add this note to heading on map sheet, using this type style, size, and spacing — *Pamphlet accompanies map* — SI-10

PURPOSES OF STYLE GUIDE

(Additions and deletions were made to the original I-2182, a color map, for example purposes only)

Guidelines shown on this sheet (from the Cartographic Technical Standards of the U.S. Geological Survey, 1978, and recent updates) are provided as an aid in preparing your map or creating a style sheet with your own software. The sheet shows components that an average map might contain, but it cannot show all possibilities and all the technical standards. If you need additional information, please consult a map editor.

These guidelines are based on standards that cartographers follow routinely, but they should be used with good judgment and common sense. Spacing, leading, type sizes, and line weights can be increased or decreased depending on the size of features shown, complexity of the map, and overall sheet or plate size.

Two groups of type styles are used on USGS maps: (1) the serif group (such as Souvenir, Times Roman, or New Century Schoolbook) and (2) the sans serif group (such as Univers, Helvetica, or Optima). Serifs are the little feet at the ends of strokes of letters; they create a consistent horizontal direction at the ends of strokes. Sans serif type does not have the little feet and does not show the same contrast of thick and thin strokes that is found in serif type.

Souvenir and Univers fonts were used for this map, and the font size and leading reflect that. However, you may use other type styles so long as serif and sans serif styles are used as indicated on this style guide and the font size and leading are adjusted accordingly. For instance, if Times Roman is used, we suggest adjusting the font size and leading from 9/11 to 10/12 for legibility and a conservative use of space.

EXPLANATION

Type style and font size
- S-9 Serif—Showing font size in points
- SI Serif italic
- SB Serif bold
- SBI Serif bold italic
- Sans Sans serif
- SansB Sans serif bold
- SansI Sans serif italic
- 3 Ld Leading (space between lines of type)—In points
- 12/15 Type size/type size plus leading—In this case, 12-point/12-point type plus 3-point leading
- 0.006 (0.15) Measurement for spacing or lineweight—In inches (millimeters)
- □ Em space—Used to show indents, square is point-size of type being used. An em in 8-point type is 8 points wide by 8 points high, and an em in 9-point type is 9 points wide by 9 points high
- 1/M Long dash (1 em)—Option, Shift, dash on Microsoft Word

BRANCH OF PRINTING SIZES FOR MACHINE-FOLDED MAPS

Sheet size (in inches)	Maximum image size (in inches)
35 x 45	32.5 x 43
36 x 54	33.5 x 52
42 x 58	40 x 56

The absolute maximum image area available is 41 x 56 inches

STYLE GUIDE
(VERSION 1.4)

[Previous versions prepared in the Western Publications Group]