State of Oregon
Department of Geology and Mineral Industries
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**Open-File Report O-07-05**

# GEOLOGIC COMPILATION MAP OF PART OF THE UPPER KLAMATH BASIN, KLAMATH COUNTY, OREGON

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# TABLE OF CONTENTS



# LIST OF FIGURES



# LIST OF TABLES



# LIST OF MAP PLATES

## INTRODUCTION

The Upper Klamath Basin is located in south-central Oregon (Figure 1). It encompasses the drainage and tributaries of the uppermost watershed of the Klamath River (Figure 2). The river flows out of Oregon into California in the southwest corner of the basin and reaches the Pacific Ocean in northern California. Major tributary rivers to the Klamath within the Upper Basin include the Wood River, the Williamson River, the Sprague River, and the Sycan River. The Lost River also flows through the east side of the basin and in prehistoric times was connected during spring flooding seasons to the Klamath River. It is presently loosely connected to the Klamath River through the irrigation systems of the Upper Klamath Lake Reclamation Project. Several large lakes currently occupying the valley floors are remnants of much larger prehistoric lakes. These lakes include Upper Klamath Lake, Lake Ewana, Round Lake, Aspen Lake, Long Lake, Lower Klamath Lake, Tule Lake, Lake of the Woods, and Swan Lake.

Recent mapping efforts in the basin by the Oregon Department of Geology and Mineral Industries (DOGAMI) began in the late 1990s with new 1:24,000 scale mapping within the Klamath Falls urban growth boundary in support of earthquake hazard analysis. As water issues within the basin became more important, DOGAMI continued making new, large-scale geologic maps in support of the hydrologic studies of the Oregon Department of Water Resources and the U.S. Geological Survey (USGS) Water Resource Department. Over the years seven DOGAMI geologists worked at various times to make new 1:24,000 scale geologic maps. The mapping was principally funded by departmental funding, grants from the Hatfield Committee, funding from the USGS Statemap program, and various other smaller funding sources. Other recent mapping efforts in the area include the private research in the Cascade Mountains by Stanley Mertzman (Franklin and Marshall College), the USGS sponsored mapping of the Crater Lake National Park by Charles Bacon, and the USGS Edmap program funded mapping and hydrologic studies of the Klamath Marsh area by Michael Cummings and his students at Portland State University.

Work on the present compilation map began in the spring of 2005 with funding from the U.S. Bureau of Reclamation. Supplemental funding was given by the U.S. Forest Service. Reconnaissance field mapping of 17 quadrangles focused on sampling of locatable volcanic eruptive points and sampling and observation of lava flow sections exposed in major fault escarpments. Final reconnaissance-level maps were drawn on the basis of these observations and analysis of aerial photographs. Approximately one week of field time was spent in each quadrangle.

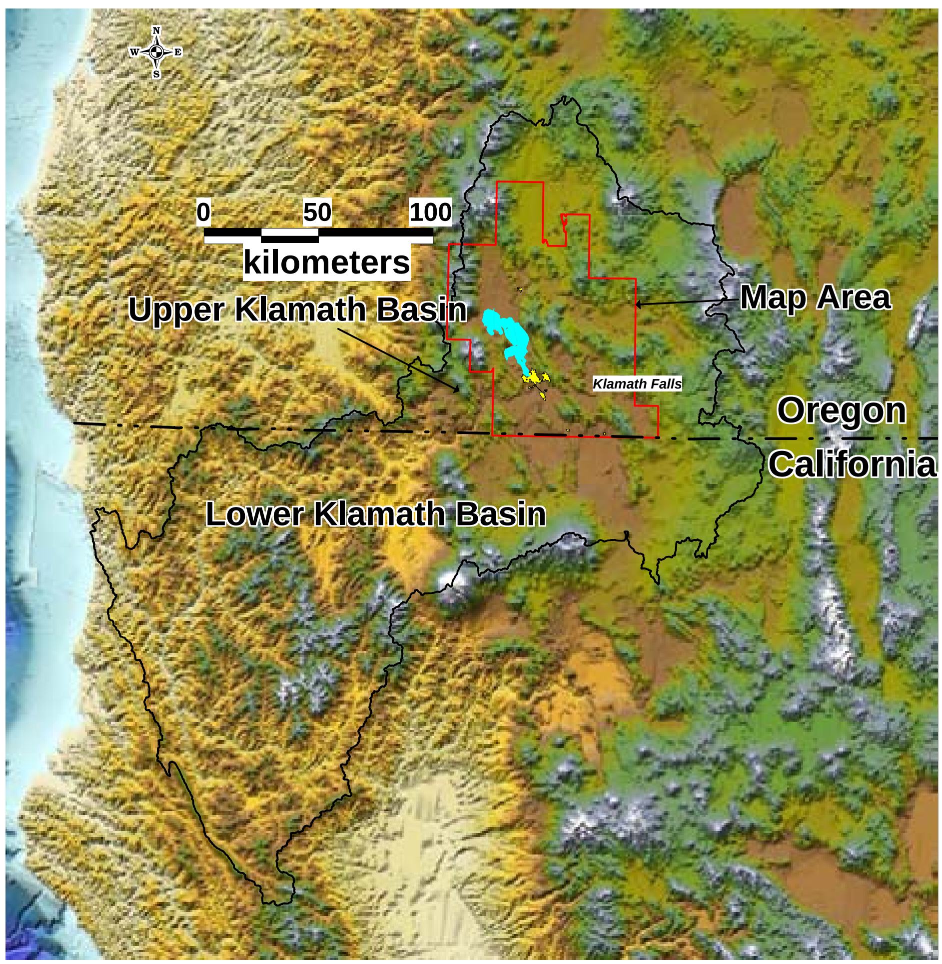


**Figure 1.** Location of the Upper Klamath Basin. The red outline shows the extent of the basin in Oregon.

## CONTRIBUTING AUTHORS

The following lists in alphabetical order the authors who contributed their mapping to this compilation. In parentheses following each quadrangle name is the number of the quadrangle, for example (35), as shown on the location map of the Upper Klamath Basin (Figure 2).

Table 1. Geologic quadrangle maps used for Upper Klamath Basin geologic compilation map.

| | Quadrangle Map | | |
|---|---|---|---|
| **Contributing Geologist and Affiliation** | **Published** | **Unpublished** | **Reconnaissance** |
| Charles Bacon, U.S. Geological Survey | | Sun Pass (3)<br>Pothole Butte (1) | |
| Gerald Black, DOGAMI, retired | Lorella (40) (2004) | Yonna (33)<br>Sprague River West (25)<br>Buttes of the Gods (17) | |
| Michael Cummings, Portland State University Geology Department | | Soloman Butte (9) | |
| Frank Hladky, formerly with DOGAMI | Bonanza (39) (2003a)<br>Dairy (38) (2003b)<br>Keno (35) (2002) | Agency Lake (14)<br>Chiloquin (15)<br>Beatty (27)<br>Sprague River East (26)<br>Hamaker Mountain (41)<br>Lost River (43) | |
| Margaret Jenks, DOGAMI | Bryant Mountain (46) (2004)<br>Langell Valley (47) (2004)<br>Malin (45) (2003) | S'ocholis Canyon (16)<br>Worden (42) | Whiteline Reservoir (31)<br>Yainax Butte (34)<br>Swan Lake (32)<br>Swan Lake Point (24)<br>Applegate Butte (10)<br>Cooks Miuntain (18)<br>Spodue Mountain (19)<br>Calimus Butte (11)<br>Modoc Point (23)<br>Fuego (4)<br>Lenz (2)<br>Sun Pass (3)<br>Pothole Butte (1)<br>Mares Egg Spring (7)<br>Crystal Spring (13)<br>Pelican Bay (21)<br>Buckhorn Springs (5) |
| Ian Madin, DOGAMI | Merrill (44) (2003) | | |
| Stanley Mertzman, Franklin and Marshall College Geology Department | | Lake of the Woods North (20)<br>Pelican Butte (12)<br>Aspen Lake (28)<br>Devils Peak (6) | |
| Robert Murray, consulting geologist | | Wocus (30) | |
| George Priest, DOGAMI, retired | | Altamont (37)<br>Klamath Falls (36) | |
| Tom Wiley, DOGAMI | Fort Klamath (8) (2004) | Howard Bay (29)<br>Shoalwater Bay (22) | |

DOGAMI is Oregon Department of Geology and Mineral Industries. Two-digit numbers in parentheses are quadrangle numbers in Figure 2. Four-digit numbers are publication years for cited published maps.

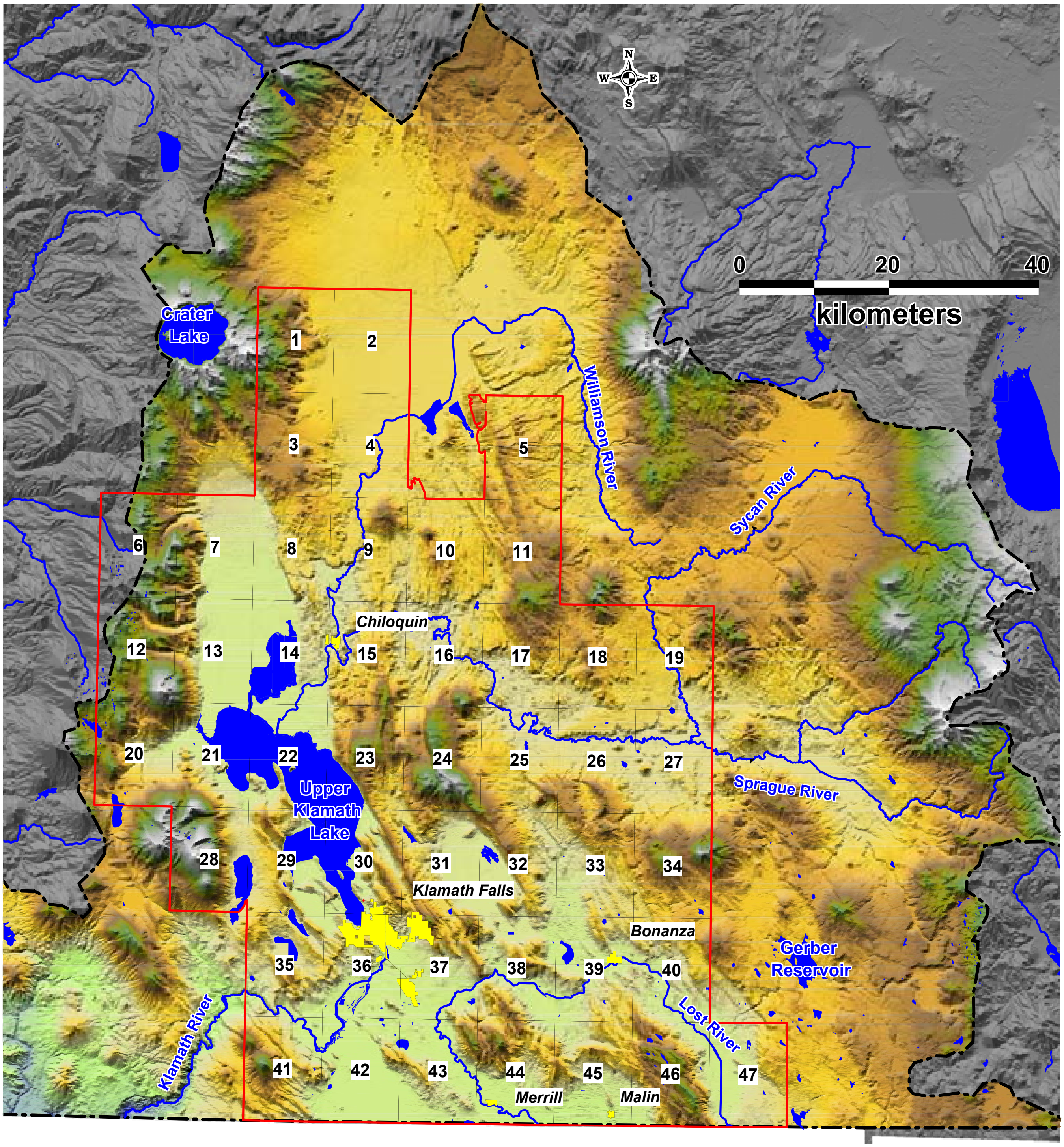


**Figure 2.** Map of Upper Klamath Basin, Oregon, showing source geologic quadrangle maps. Numbers on the figure correspond to geologic quadrangle map numbers in Table 1.

## PREVIOUS WORK

Peterson and McIntyre (1970) mapped the eastern part of Klamath County as well as the western part of Lake County at a scale of 1:250,000. They divide the area into 23 units. Their report provides a basic description of the units, a list of fossil localities, and an extensive discussion of the area's mineral resources.

Sherrod and Pickthorn (1992) mapped the west half of the Klamath Falls 1° × 2° quadrangle at a scale of 1:250,000. They divided the area into 30 units and obtained 21 new radiometric rock age dates.

## PRODUCT COMPONENTS

In addition to this text, this product includes Geographical Information System (GIS) spatial data layers, map plates created from the GIS data (Plate 1 and Plate 2), and data spreadsheets. File names are in italic text.

### Spatial layers

- Geology polygon layer (*GEOLOGY*) — Attributed with two different theme labels: map_unit (1:100,000 scale Upper Klamath Basin (UKB) compiled geologic units) and hydro_unit (more generalized lithology/hydrogeology units); see *UKB units legend.xls* spreadsheet, below, for label explanation for each unit
- Fault line layer *(Faults)* — Attributed with quad_name, fault_name (name given to major fault traces), trace_type, side_down (the side of the fault that has moved down relative to the upper fault block), and trace_cert (location of the fault: certain, approximate, or concealed)
- Geochemical samples point layer (*Geochem*) — Attributed with quad_name, sample_no, utm_e and utm_n (location coordinates), iugs_cla,s (International Union of Geological Scientists [IUGS] volcanic lithology classification type [Le Bas and Streckeisen, 1991]), auth_unit (the contributing author's original geologic unit label), and chem_type (Upper Klamath Basin chemical type; see *UKB chemical types legend.xls* spreadsheet, below, for label explanation for each unit)
- Radiometric age samples point layer (*Age*) — Attributed with sample_no, age_ma (radiometric age date in millions of years), quad_name, source (publication or contributing author's name), and utm_e and utm_n (location coordinates)
- Volcano eruptive point layer (*Volc_loctn*) — Attributed with quad_name, volc_type (general type of volcano: H, hydrovolcanic; V, subaerial vent; or C , cinder cone), volc_name (name given to the topographic feature that is the vent area of the volcano), and utm_e and utm_n (location coordinates)

### Spreadsheets

- Legend for geology and lithology/hydrogeology unit polygon labels with unit names and applicable radiometric ages (*UKB units legend.xls*)
- Geochemical analysis results (*UKBgeochemical analyses.xls*)
- Definitions of UKB geochemical volcanic types from the $SiO_2$, $TiO_2$, and $Al_2O_3$ analysis results, their IUGS classification rock type, their comparative relationships (H, high; M, medium; L, low), and their numerical percent ranges (*UKB chemical types legend.xls*)
- Radiometric age date synthesis (*UKB age synthesis.xls*)

## MAPPING AND COMPILATION METHODOLOGY

### Field methods

Contributing authors used a variety of methods for their field work. These methods include walking out contacts between rock units of different types, sampling and making observations at specific locations, locating samples with GPS and field computers as well as on paper topographic maps, and writing logs of observations and sample locations. Field observations are enhanced by observation of aerial photographs, analyses of sample rocks for their geochemical compositions and their radiometric ages, and thin section study of rock samples. The original geologic maps, before compilation, were all completed on 1:24,000 scale USGS standard topographic base maps.

## Compilation methods

The only equivalent data available throughout the study area were geochemical analyses. To compare analyses, first, all analyses were normalized and plotted on the IUGS volcanic rock classification (Le Bas and Streckeisen, 1991) diagram ($SiO_2$/Total alkali). Several different elemental comparisons were then tried, including Ba/$SiO_2$, Sr/$SiO_2$, Ba/K, and Sr/K. None yielded consistent lithology group results throughout the database. Finally, analyses were sorted by $K_2O$ within each IUGS volcanic rock classification. The amounts of $SiO_2$, $TiO_2$, and $Al_2O_3$ were compared and classified according to their relative percentages (high, medium, low). This methodology created generalized classes of volcanic rocks, which were assigned alphanumeric labels (for example, Tand6 and Tbas10). These classes were then plotted spatially and compared to the original author's map units. A unit label, composed of the age of the unit from the radiometric ages and stratigraphic relations in the vicinity and the informal geologic unit name, was assigned for each area of similar unit and class type. Lithologic/hydrogeologic units were assigned only on the basis of age and IUGS rock classification type.

# SIGNIFICANT OBSERVATIONS

The compiler made the following list of observations on the basis of her published, unpublished, and reconnaissance mapping and her compilation of other authors' observations and mapping. Although most of the observations resulted from the compiler's direct field observations, they are not the conclusions or opinions of the other authors who contributed geologic mapping and information to the project.

1. Volcanic activity within the basin has been nearly continuous during the last 8 million years, with no significant breaks, given our present understanding of radiometric ages of the basin's volcanic rocks.
2. A major part of the area is underlain by volcanic rocks and sediments ranging in age from 2.0 to 5.0 Ma (Pliocene).
3. The seemingly pervasive sequences of subaerial lava flows underlying the topographic surfaces throughout the basin are recent, thin caps of lava flows over diverse sections of thick older sediments, hydrovolcanic deposits, and water-affected lava flows.
4. Faults, especially large valley bounding faults, are made up of a number of parallel fault planes.
5. The parallel fault planes successively downdrop the capping volcanic units, creating repeated sections in the fault escarpments.
6. Faulting not only creates steep escarpments but also tilts the upper surfaces of the lava flows or sediments up and away from the fault escarpment.
7. Faulting of the basin by normal faults is fairly recent, beginning 1.5 to 2.0 million years ago
8. Fault escarpments show very little stream dissection, and the valley floor alluvial fans at the bases of the escarpments are small.
9. Previous to the late Pliocene/early Pleistocene faulting the landscape was fairly level with some low hills of older calc-alkaline volcanic rocks surrounded by the flows of the younger basaltic rocks.
10. Most of the basin's volcanic flows and sedimentary and volcanic detritus principally spread out over nearly horizontal ground surfaces.
11. Valley filling by lava flows is found only in the northern part of the area, particularly in relation to the Sprague River and Sycan River ancient drainages.
12. Valley-confined lava flows filled broad, shallow valleys rather than steep-sided, deep canyons.
13. Faulting in the southern part of the basin is more intense and extensive, with dominant structural grains including northwest-southeast, east-west, and north-south.
14. With the exception of the northern part of the Upper Klamath Lake graben, faulting in the northern part of the basin is less intense and extensive, with smaller displacements on the fault escarpments and a general north-south structural grain.
15. Volcanic lithologies are variable, ranging from rhyolites to trachybasalts.
16. Volcanic sequences, trending upward from calc alkaline to more primitive tholeiitic, are repeated across the area from east to west and south to north.
17. The volcanic activity becomes younger from east to west.

18. The volcanic sequences are repeated through time from east to west.
19. Nearly 470 volcanic vents are located in the basin area.
20. In volume, the eruptive products from the individual volcanic vents are not large and are localized around the vent/vents that erupted them.
21. With the exception of Mount Mazama, the volcanoes in the area were erupted as single-episode events, confined to specific, short periods (tens of thousands to hundreds of thousands of years)
22. Stream and river drainage locations are determined by faulting or lava flow edges.
23. Significant deposition of finer grained, lake and low-gradient stream sediments has occurred throughout the basin's geologic history.
24. Interlayered with the sediments throughout the geologic history of the basin are hydrovolcanic units including hydroclastic cinder cones, water affected basalt flows, and pillowed basalt flows.
25. Significant erosion occurred following the deposition of sediments and hydrovolcanic units and before the deposition of the capping subaerial lava flows.
26. Much of the present topography on the south side of the Sprague River Valley is exhumed terrain.
27. Most of the hydrovolcanic eruption exposures have been removed by erosion, leaving only the volcano's cemented central vent "root" deposits.
28. Glaciation in the Cascade Range on the west side of the area was extensive and sheetlike.
29. Glaciation in the Cascade Range was disrupted by both faulting and subsequent post-glacial valley-formation lava flows.
30. Faulting on the west side of the Upper Klamath Lake is younger than the end of the latest glacial period and cuts moraine and alluvial fan deposits in numerous locations.
31. Above the elevation of approximately 1,800 m (6,000 ft), valley glaciers have carved the landscape throughout the area east of Upper Klamath Lake.
32. Valley glaciers have followed fault valleys and escarpments as well as lava flow edges.
33. Most larger alluvial fans in the basin are actually glacial fans formed by glacial debris at the ends of the valley glaciers.
34. Most springs, both hot and cold water, in the basin are located along valley bounding faults.
35. The Mazama ash deposits on the east side of the Klamath Marsh blanket but do not fill a pre-existing terrain of lava flows and dissected sediments.
36. Subsurface water flows within the Mazama ash deposits are directed in part by the underlying pre-existing terrain.
37. Pre-existing glacially eroded valleys on the east side of the Mazama volcano were the pathways/guideways for the Mazama eruption ash flows.
38. Large pothole features, found in the Mazama deposits in three separate areas, may be the result of the post-eruption melting of large blocks of glacial ice.
39. A well-established, post-eruption, low-gradient drainage pattern on the west side of the Klamath Marsh has been affected by post-eruption faulting and has been replaced with a present-day incisional drainage pattern.
40. Fish fossils from the mapped area all yield relative ages of 4.0 to 6.0 Ma (Pliocene), with a juvenile spawning population found in one locality.

## ACKNOWLEDGEMENTS

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