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LATE QUATERNARY PALEOLAKES OF BUTTE VALLEY, SISKIYOU COUNTY, CALIFORNIA

Guy King

At times of decreased temperature and/or increased precipitation during the 1.8 million years spanning the Quaternary Period, most hydrologically-closed drainage basins in the Western United States contained lakes that were larger than at present (Figure 1). Most of these Quaternary paleolakes, such as Lakes Bonneville and Lahontan, were located in the Great Basin which is the largest contiguous area of closed drainage on the North American continent. However, a few paleolakes occurred west of the Great Basin. The largest of these were Lake Le Conte which occupied the Salton Sea Basin and had a maximum area of 4600 km^2, Quaternary Tulare Lake which had a maximum area of 4100 km^2, and Modoc Lake which occupied the Klamath Lakes Basin with a maximum area of 2800 km^2 (Smith and Street-Perrott 1983, Dicken 1980). One of the smaller Quaternary paleolakes occupied Butte Valley, located just south of the Klamath Lakes Basin in northeastern Siskiyou County. At its greatest extent, the Butte Valley Basin Quaternary paleolake was 189 km^2 in area and had a maximum depth of 14 m.

The purpose of this study is to examine the late Quaternary paleolake history of Butte Valley. Field work during August of 1994 was undertaken at the request of the Archaeological Research Program of California State University, Chico which is conducting ongoing excavations at the Butte Valley Wildlife Area for the California Department of Fish and Game. No extensive study of Butte Valley Quaternary paleoenvironments had been done. Previous work on the paleoenvironments of the Butte Basin have been done as part of the geological surveys of

Dr. King is an Associate Professor in the Department of Geography and Planning at California State University, Chico.

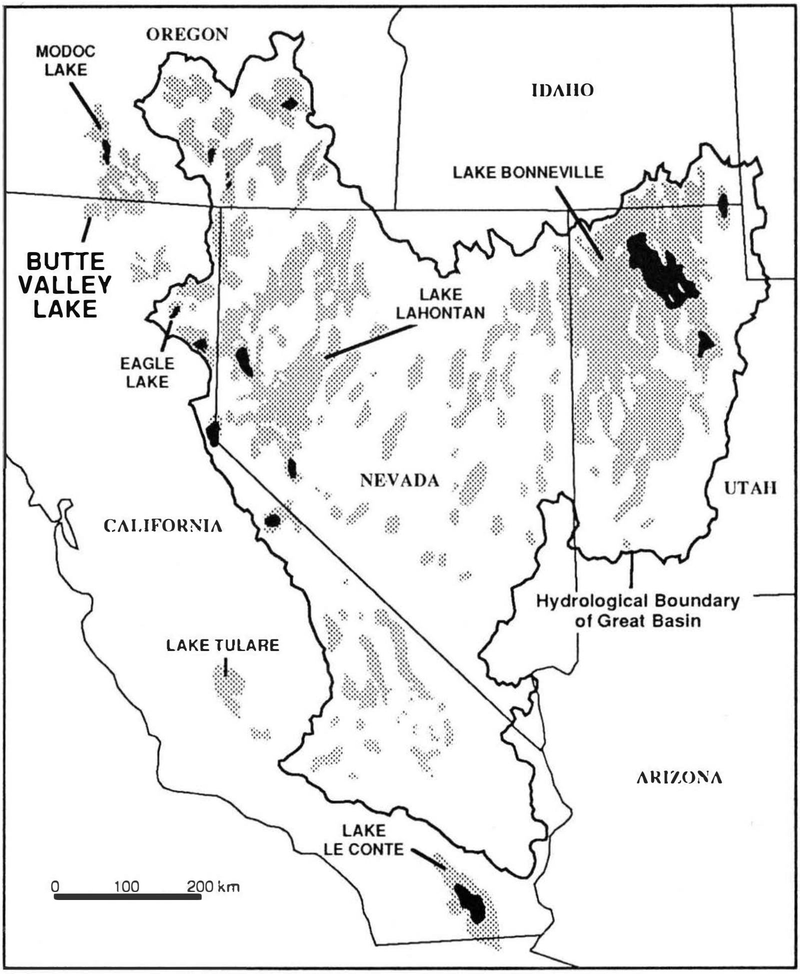

Figure 1. Quaternary Paleolakes of the Western United States. Modern lakes shown in black.

Wood (1960) and Williams (1949) who, respectively, briefly mention the Quaternary lacustrine and glacial deposits of the Basin.

Hydrologically, Butte Valley is a closed drainage basin that lies between the Klamath River Basin to the north and the Sacramento River Basin to the south. Geologically, Butte Valley is located in the Modoc Plateau transition zone between the Cascades continental volcanic arc to the west and the Basin and Range Province of normal faulting to the east

(Thornbury 1965). The late Quaternary history of the Butte Valley Basin is dominated by both extensive volcanic eruptions, and wide-spread normal faulting.

The major Quaternary paleoenvironmental features of the Butte Valley Basin are the shorelines and lake deposits left by relatively extensive lakes that occupied the valley floor, and the glacial moraines and cirques found in the headwaters of Butte and Antelope Creeks.

The Butte Valley Drainage Basin

The present closed drainage basin of Butte Valley is approximately 1115 km^2 in extent (Figure 2). The lowest elevation in the Basin is 1288 m at the bottom of Meiss Lake, while its highest elevation is the top of The Whaleback at 2599 m in the southwestern part of the drainage basin. Between the Whaleback and Haight Mountain to the east, lie the headwaters of Butte Creek which is the largest stream feeding into Butte Valley.

Drainage changes caused by late Quaternary Volcanism. As the result of Cascadian volcanic activity, the drainage basin of Butte Valley has undergone major changes during late Quaternary time. Lava and pyroclastic eruptions have disrupted the drainage of the area so that past tributaries of Butte Creek have been cut off to form their own closed basins. Two examples illustrate these drainage changes. The first is Antelope Creek, which lies to the east of Butte Creek. Like Butte Creek, Antelope Creek's headwaters are in high mountains that were glaciated during the Quaternary. Eruption of the Butte Valley Basalt flows during late Pleistocene and/or Holocene time (Wood 1960: 29) resulted in Antelope Creek being cut off from the Butte Creek drainage basin. At present, the Creek ends in Antelope Sink, which is just south of Cedar Mountain (Figure 2). An abandoned distributary channel that splits off from Antelope Creek about one kilometer upstream from the community of Tennant shows Antelope Creek has recently flowed into Round Valley. Evidence from aerial photographs and topographical maps suggests that Round Valley contained a late Quaternary lake that overflowed into the Butte Creek drainage basin. The addition of the Antelope Creek drainage basin to the Butte Valley Basin would add approximately 208 km^2 of watershed area.

The second example of recent drainage changes in the Butte Valley Basin involves the Grass Lake area which lies to the west of Butte Creek. Lava flows from both Deer Mountain and Little Deer Mountain volca-

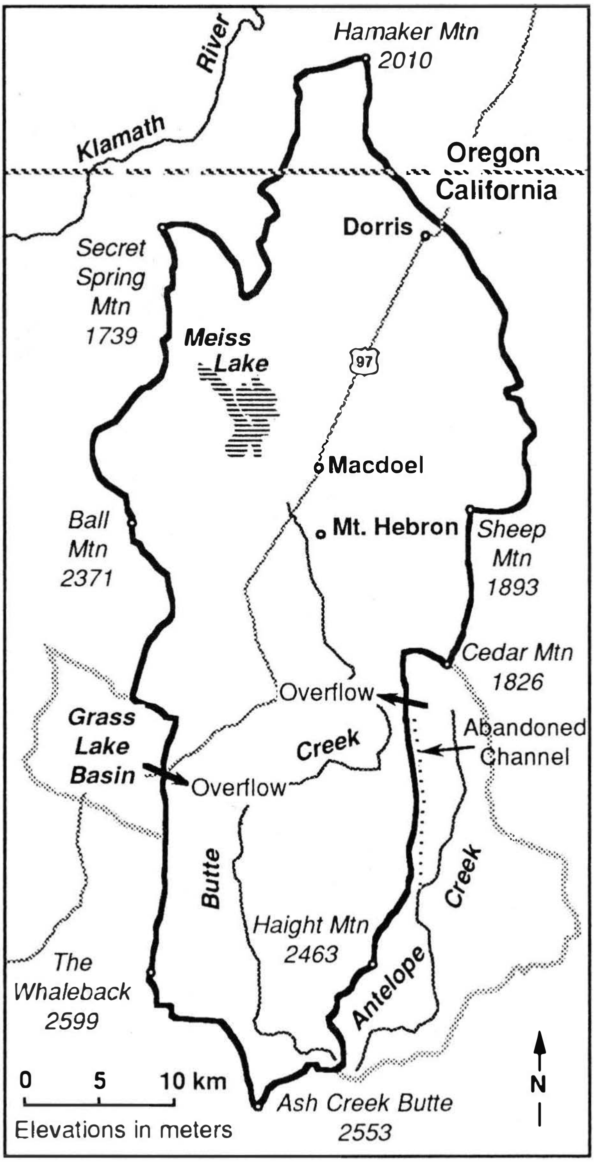

Figure 2. The Butte Valley drainage basin.

noes (Williams 1949), just east of Grass Lake, cut the drainage of this area off from Butte Valley during late Pleistocene and/or Holocene time. The present Grass Valley drainage basin is about 72 km^2 in extent.

Late Quaternary glaciation in the Butte Valley drainage basin. Both Wood (1960: 38) and Williams (1949: 45) mention the alpine glacial evidence in the the Butte Creek watershed. Multiple cirque glaciers developed in upper Butte Creek and Alder Creek, which is a major tributary to Butte Creek in its upper part. The cirques produced by these glaciers are north or northeast facing and extend from about 2040 m down to about 1950 m elevation. The glaciers from these cirques produced a valley glacier approximately 19 km long at its maximum extent. Below the moraines deposited by this valley glacier are glacial outwash deposits which extend for another 3 km.

The upper watershed of Antelope Creek was also glaciated. Since Antelope Creek drained into Butte Creek during late Quaternary time, its glaciation evidence is relevant to the history of Butte Valley. The multiple cirque glaciers of Antelope Creek are fewer in number and cover a smaller area than those in the Butte Creek Basin. Antelope Creek glacial cirques are north or northeast facing and extend from about 2135 m to about 1950 m elevation. Antelope Creek Lakes and Hemlock Creek Lake occupy the largest cirques in the Antelope Creek Basin.

The Butte Valley paleolake

Scattered occurrences of lake-shore terraces around the edges of Butte Valley and extensive lake deposits on the valley floor are evidence of a large paleolake that covered Butte Valley. At its maximum elevation of about 1301 m, this paleolake had a perimeter of 104 km, and an area of 189 km^2 (Figure 3). At maximum elevation, the deepest part of this lake, which occurs in the bottom of present day Meiss Lake, was 14 m. The Butte Valley paleolake is comparable with Quaternary Eagle Lake in Lassen County which, at maximum extent, was 142 km^2 in extent and 18 m deep (Snyder, Hardmen, and Zdenek 1964).

Shore terrace evidence in Butte Valley. Compared to larger Quaternary paleolakes such as Lahontan in northwestern Nevada and Bonneville in western Utah, the paleolake shoreline evidence in Butte Valley is meager. Overall, the Butte Valley shore terraces are weakly developed and scattered in their occurrence. A major problem with study-

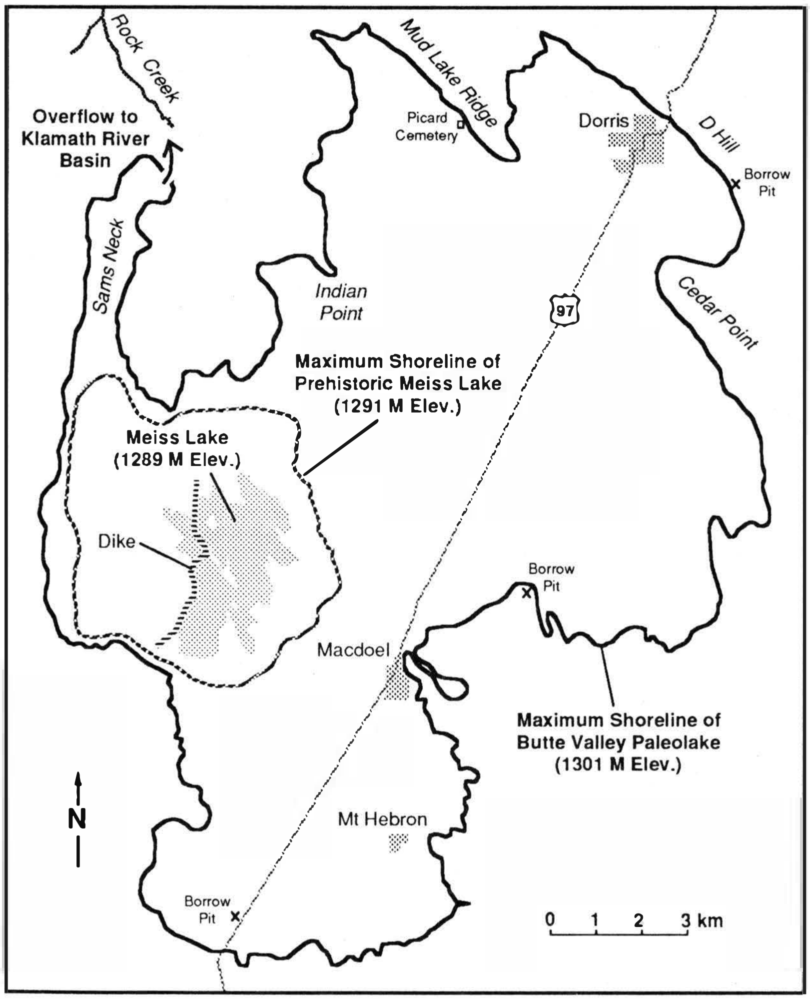

Figure 3. Butte Valley showing Quaternary lake shorelines.

ing shore terraces in Butte Valley is their disturbance by human activity. There are about fifty ranches in Butte Valley (Lantis, Steiner, and Karinen 1989). A number of Butte Valley ranchers have constructed houses and other buildings on the top of the terraces, and in many places the roads along the edge of Butte Valley have been built on the terraces.

The best developed shoreline terrace in Butte Valley occurs at the paleolake overflow elevation of 1301 m. The widest 1301 m elevation terraces occur in Butte Valley on its north and east sides. A good example of a 1301 m terrace occurs along the southwestern edge of Mud Lake Ridge near Picard Cemetery (SE. 1/4, Section 28, Township 48 N., Range 1 W.). Another good example of a 1301 m terrace is developed along the southwestern edge of D Hill just east of Dorris (NW. 1/4, Section 32, Township 48 N., Range 1 E.). In the area of the latter 1301 m elevation terrace occurrence, eolian sand deposits associated with the shore terrace are exposed in a borrow pit just north of the Dorris-Bromwell Road (NE. 1/4, Section 5, Township 47 N., Range 1 East).

Other weaker paleolake shorelines occur in Butte Valley at elevations of approximately 1299 m and 1297 m. An example of the 1299 m elevation shore terrace occurs on the end of Indian Point (SW 1/4, Section 7, Township 47 N., Range 1 W.). This 1299 m terrace is approximately 10 m wide and consists of coarse beach sand with scattered angular talus boulders. A good example of the 1297 m elevation shore terrace is located on the west side of Cedar Point (W 1/2, Section 7, Township 47 N., Range 1 E.). Wood (1960: 44) thought the Cedar Point terrace was produced by faulting.

The topography of Butte Valley is such that below the 1297 m elevation terrace, the shallow sloping valley floor is encountered resulting in a lack of paleolake shoreline evidence. A major problem encountered with looking for shoreline evidence on the floor of Butte Valley is its disturbance by agricultural activity. Many ranchers have leveled large parts of the valley floor for cultivation of crops.

Other Quaternary Lacustrine Evidence in Butte Valley. Aside from shore terraces, additional evidence for the Quaternary paleolakes in Butte Valley consists of lake, deltaic, and aeolian sand deposits. As mapped by Wood (1960), the floor of Butte Valley is mostly composed of fine-grained Quaternary lake sediments. Most of the surface exposures of these lake sediments have been disturbed by agricultural activity. The leveling of fields in many parts of the valley has destroyed much of its original surface. For example, the areas of two small playas along the southeastern side of the Valley shown on the older United States Geological Survey 15 minute topographical maps are now cultivated fields.

However, the area east of Meiss Lake contains an extensive remnant of undisturbed lake deposits that have never been cultivated. This area consists of exposed Quaternary lake beds of silt, clay, and fine sand that highly resembles a playa surface. Since desiccation of the Butte Valley paleolake, this surface has been colonized by scrub vegetation. The trapping of aeolian silt and fine sand by the stems of the scrub plants has resulted in phytogenic dune development on the lake bed surface. These phytogenetic dunes extend up to two meters in height and are very similar to the phytogenetic dunes developed on Pleistocene lake deposits found adjacent to modern Great Basin playas (Young *et al.* 1986). Dominant vegetation on these dunes is sagebrush (*Artemisia tridentata*). Smaller dune mounds are formed by greasewood (*Sarcobatus vermiculatus*) and desert peach (*Prunus andersonii*). In between the phytogenetic dunes the dominant vegetation is rabbitbrush (*Chrysothamus nauseosus*). Scattered western juniper (*Juniperus occidentalis*) trees also occur throughout this area of undisturbed lake deposits.

In some places between Meiss Lake and Dorris, slightly higher phytogenetic dunes ridges occur that trend northwest/southeast in parallel with the basin and range fault trend of the area. This suggests that these phytogenetic dune ridges are formed along fissures in the lake beds produced by basin faulting. Increased scrub vegetation occurs along the fissures because of increased moisture availibility.

Evidence from well logs indicates that the Butte Valley lake sediments are hundreds of meters deep in places (Wood 1960: 39). This is evidence that Butte Valley has contained much older Quaternary lakes than the more recent ones that formed the shore terraces along the edges of the Valley. Additional evidence for older lakes are the Quaternary pyroclastic deposits that were mapped by Wood (1960: 26-28). In a borrow pit just northeast of Macdoel (SE. 1/4, Section 3, Township 46 N., Range 1 W.) exposures of these pyroclastic rocks reveal they were laid down in lake water (Wood 1960: 28). Cross bedding in these sediments indicates they were deposited in a near-shore zone.

Along the area where Butte Creek crosses the shoreline of the maximum Quaternary lake elevation (1301 m) in Butte Valley, exposures of possible deltaic sediments occur. A good exposure of these sediments is in a borrow pit adjacent to Highway 97 as it enters Butte Valley (N. 1/2, Section 10, Township 45 N., Range 2 W.). These sediments consist of granule and pebble sized gravels overlain by silty pebbly material.

Extensive aeolian dune deposits, mapped by Wood (1960), occur south of Cedar Point. The majority of the sand in these aeolian deposits most likely was produced by wave action along the eastern shorelines of the Quaternary Butte Valley lake. Wood (1960: 46) considered some of the aeolian sand to be reworked stream alluvium.

Evidence for Quaternary Paleolake Overflow in Butte Valley. A small notch eroded to the elevation of approximately 1300-1301 m is located at the end of Sams Neck (NE. 1/4, Section 34, Township 48 N., Range 2 W.). This notch is tied to the Pleistocene Butte Lake shoreline at 1301 m elevation. Overflow was into Rock Creek which is tributary to the Klamath River located about six kilometers north of Sams Neck. The overflow of the Quaternary Butte Valley paleolake apparently was of short duration. This is indicated by the lack of a distinct overflow channel connecting the Sams Neck notch with the Rock Creek channel. In addition, the narrowness and scattered occurrences of the 1301 m shore terrace in Butte Valley also suggests that Quaternary Butte Valley paleolake overflow was brief.

The overflow of the Quaternary paleolake in Butte Valley can be compared to that of Quaternary Eagle Lake. Guyton's (1973) research indicates that a distinct channel was produced by the overflow of Quaternary Eagle Lake into the Lahontan Basin. Though more topographically-developed than the Butte Valley overflow channel, the Eagle Lake overflow channel is not deeply-eroded either. Guyton (1973) inferred that the lack of clastic material in the lake overflow discharge and the resistance of the basalt bedrock were responsible for the lack of a deeply-cut overflow channel. This explanation may partly explain the lack of a well-developed overflow channel for the Quaternary Butte Valley paleolake.

However, the best evidence for a short-lived Quaternary Butte Valley paleolake is the lack of a well-developed and widely-occuring shore terrace at the overflow elevation of 1301 m. In contrast, Guyton (1973) describes a broad, well-developed shore terrace at the overflow elevation for Pleistocene Eagle Lake that is found around the entire Eagle Lake basin. In fact, the lack of any well-developed shorelines in Butte Valley indicates that for the most part the lake was confined to valley floor elevations.

Prehistoric Meiss Lake in Butte Valley

The floor of Butte Valley is broken up into two shallow sub-basins. The eastern sub-basin, prior to intensive agriculture during this century, contained several small playas. Most of these playas have been destroyed for cultivation. Meiss Lake occupies the western sub-basin. Williams (1949: 54) thought that the Meiss Lake Basin was produced by faulting. However, the low divide between the western and eastern sub-basins must have been partly formed by deposition of Butte Valley Basalt during the late Pleistocene. This lava flow is buried by shallow Pleistocene lake deposits (Wood 1960: Plate 3).

Meiss Lake occupies a shallow basin with its lowest point being 1288 m elevation. The Lake is fed primarily by ground water seepage, spring discharge, and Prather Creek (Wood 1960; Williams 1949). Butte Creek probably also fed into prehistoric Meiss Lake during high flow periods, but all surface evidence of the lower Butte Creek channel has been destroyed by cultivation. The level of Meiss Lake fluctuates with changes in the ground water table (Wood 1960). To prevent flooding of cultivated land, the Lake has been extensively diked on its western shore during this century (Figure 3). Now when Meiss Lake rises in level its excess water is pumped, via a canal through the Sams Neck gap, into the Rock Creek drainage.

Because of the shallow topography of the Meiss Lake Basin, small changes in its lake level are accompanied by relatively large changes in lake area. In the area east of modern Meiss Lake (E. 1/2, Section 36; and W. 1/2, Section 31, Township 47 N., Range 1 W.), two shorelines can be identified based on aerial photography interpretation of soil and vegetation development. The area below the lower shoreline, which is at an approximate elevation of 1290 m, is covered with grasses and represents the historic high level of Meiss Lake. The area between the lower and the higher shoreline of Meiss Lake, which is at an approximate elevation of 1291 m, is covered by grasses and scattered scrub, suggesting a prehistoric age. The area above the 1291 m shoreline is covered with scrub vegetation similar to that, described above, developed on the Quaternary lake deposits of the floor of Butte Valley. At the maximum shoreline elevation of 1291 m, the depth of prehistoric Meiss Lake was 3 m. The perimeter of prehistoric maximum Meiss Lake was approximately 22 km, while its area was approximately 30 km^2.

It is possible that prehistoric Meiss Lake overflowed into the eastern sub-basin of Butte Valley. However, given the shallow topography and small area of the eastern sub-basin of Butte Valley, any overflow from

Meiss Lake must have been very brief and of low amounts. The eastern Butte Valley Sub-basin is very flat with its lowest elevations occurring in two playa basins that were below 1289 m (these playas have been destroyed for cultivation, their former elevations were determined from the 1950 U.S. Geological Survey 15 minute Dorris topographic Quad).

Chronology of Butte Valley paleolakes

No suitable material for radiocarbon dating was found in any of the Quaternary shore terraces or lake deposits of Butte Valley. Hence, a local absolute chronology of Butte Valley Quaternary paleolakes could not be developed. However, the general timing of Quaternary lake levels in Butte Valley can be inferred from examining evidence from surrounding areas. The development of this inferred chronology is tied to the Butte Valley paleolake evidence consisting of older lake deposits, Quaternary Butte Valley paleolake shore terraces, and the maximum prehistoric Meiss Lake shore terrace.

As discussed above, the older lake deposits of Butte Valley include fine-grained silts and clays hundreds of feet thick below the present floor of Butte Valley. They also include water-laid pyroclastic sediments exposed at elevations above the late Quaternary Butte Valley shore terraces. The ages of these older lake deposits almost certainly go back hundreds of thousands of years before the present. Closed lake evidence from the basins of Quaternary Lakes Lahontan, Bonneville, and Searles indicates that multiple deep-lake cycles occurred in those basins as far back as a million years ago (Morrison 1991).

The weakly-developed and scattered shore terraces along the sides of Butte Valley, and the lack of a significantly-eroded overflow channel through the Sams Neck gap suggests that the Butte Valley paleolake stood at the 1301 m level for only a brief period during the late Pleistocene. The levels of the paleolakes in Butte Valley were controlled by either drainage changes, which were discussed above, or climate change. High paleolake stands in closed-drainage basins are correlated with cooler and or wetter paleoclimates. Various pollen, fossil, glacial, and lacustrine evidence from numerous localities in the western United States indicates that the last full-glacial paleoclimate occurred around 18,000 years ago (Thompson *et al.* 1993). Adam and West (1983), using pollen evidence from Clear Lake, California have suggested that full-glacial maximum temperatures were 7-8°C lower than present and precipitation was 300% to 350% greater. Sierra Nevada maximum alpine glaciation was contemporaneous with this full-glacial paleoclimate

(Elliot-Fisk 1987). However, the last maximum highstands of western Great Basin Quaternary paleolakes lagged behind full-glacial paleoclimate maximum by a few thousand years (Dorn *et al.* 1990). It is unknown whether the last Butte Valley paleolake highstand is younger than, or was contemporaneous with maximum alpine glaciation in the Butte and Antelope Creek Basins.

The lack of evidence for paleolakes on the floor of Butte Valley between the 1291 m elevation Meiss Lake shoreline and the lowest shoreline elevation of 1297 m formed on the steeper slopes at the edge of Butte Valley may be due to a rapid desiccation of the Butte Valley paleolake at the end of the last glacial cycle. Current evidence from Great Basin Quaternary paleolakes indicates that they rapidly desiccated to modern levels about twelve to ten thousand years ago (Thompson *et al.* 1993).

The timing of the fluctuations of prehistoric Meiss Lake are very difficult to infer. As discussed above, the scrub vegetation development in the area between the historic 1290 m and the prehistoric 1291 m elevation Meiss Lake shorelines is less than that on the Butte Valley floor above 1291 m elevation. The phytogenetic dune mounds on the floor of Butte Valley resemble those found on Pleistocene lake sediments adjacent to modern Great Basin playas (Young *et al.* 1986). This suggests that the 1291 m Meiss Lake shoreline is Holocene in age.

The level of Meiss Lake may have been below 1290 m through most of the Holocene. Evidence for this comes from a backhoe trench excavated on the west side of the Meiss Lake Basin (S. 1/2, NE. 1/4, Section 5, Township 46 N., Range 2 W.) during August of 1994 by the California Department of Fish and Game at the request of contract archaeologists from California State University,Chico. This 2 to 2.5 m deep trench, over 150 m in length, was cut across the area of maximum shoreline elevation from approximately 1290 m to 1292 m elevation. The lake sediments exposed along the trench were deep-water silts and clays without any evidence of coarser shore zone sands and gravels. A well-defined soil profile extending to over 101 cm in depth is developed on these lake sediments which suggests that this area has been not been underwater for most of the Holocene. This soil is classified by the U.S. Department of Agriculture as the Pit Series (U.S. Department of Agriculture 1994). It is high in shrink-swell montmorillinite clays which results in large cracks (up to 0.7 m in depth) occurring upon desiccation during the summer.

Examination of the soil east of the backhoe trench, which is the historically drained Meiss Lake bed area, provides further evidence that Holocene Meiss Lake stood at levels below 1290 m through most of the Holocene. This soil, classified as the Teeters Series by the U.S. Department of Agriculture (1994), is less developed than the Pit Series. The Teeters Series has a low shrink-swell potential and is only 61 cm deep at maximum. The contrasting deeper Pit Series soil development of 101 cm suggests that it has been above Meiss Lake levels for a longer time period.

Evidence that indicates Meiss Lake was not dry for any long periods during the Holocene comes from archaeological sites along its shore areas. Archaeological investigations along the east side of Meiss Lake found evidence of prehistoric human habitation along both the 1290 and 1291 shoreline areas (Hamusek 1993a). Projectile point analysis indicated that human occupation of the eastern shore area of Meiss Lake ranged in age from 6640 to 565 years before present. An archeological site investigation on the west side of Meiss Lake found evidence of human occupation that approximately dated between 9000 to 1400 years before present (Hamusek 1993b). The elevations of the west side archaeological sites ranged between 1289 and 1290 m. The long human occupation of these lakeshore sites at different altitudes suggests that Meiss Lake contained some water through much of the Holocene.

Conclusion

Evidence for the earliest Quaternary paleolakes in Butte Valley consists of thick accumulations of deep-water silts and clays, along with water-laid volcanic pyroclastic deposits that extend above the maximum shoreline of the late Pleistocene Butte Valley paleolake. Shore terraces indicate that an extensive 14 m deep Butte Valley lake briefly overflowed into the Klamath River Basin at least once during the late Pleistocene. The lack of paleolake shoreline evidence between 1297 m and 1291 m elevations on the floor of Butte Valley indicates a rapid desiccation for the last paleolake at the end of the Pleistocene. Vegetation and soil development, and archaeological evidence along the shore areas of Holocene Meiss Lake indicate that its maximum level was 1291 m elevation, that for most of the Holocene it was below 1290 m elevation, and that it was not dry for any long periods.

The study of Butte Valley Quaternary paleolakes is significant because so little research has been done on western North American Quaternary paleolakes outside of the Great Basin. The history of the Quaternary paleolakes in the California and Oregon areas northwest of the Great Basin are unknown. By examining the Quaternary paleolakes that occupied Butte Valley, the Klamath Lakes Basin, and Big Valley (south of Butte Valley) more knowledge about the history of the late Quaternary can be gathered. The research presented in this paper is preliminary. Much more work needs to be done on the late Quaternary history of Butte Valley. A local stratigraphy for the Butte Valley paleolakes needs to determined by finding suitable material for radiocarbon dating in the shore deposits at the edge of Butte Valley and along the shores of Meiss Lake.

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