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# Late Tertiary to Quaternary Geology and Landscape Evolution along the Snake River Plain, Southwestern Idaho

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**APPENDIX VIII**

**LATE TERTIARY TO QUATERNARY GEOLOGY AND LANDSCAPE  
EVOLUTION ALONG THE WESTERN SNAKE RIVER PLAIN,  
SOUTHWESTERN IDAHO**

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## Introduction

The geology of the Snake River Plain in the vicinity of Melba and Murphy, in southwestern Idaho, provides evidence for changes that have occurred over the last several million years, during the late Cenozoic. Here, the local and regional geology is described and interpreted within the context of events that have contributed to the present-day landscape.

The region is about 30 miles southwest of Boise, Idaho (Figure 1) and is between

Melba, to the north, and Murphy, to the south. The focus of the research was the Walters Butte U.S.G.S. 7.5 minute quadrangle. Walters Butte is situated south of Melba (Figure 2). The area south of the Snake River, including Guffey Butte, is part of the Birds of Prey National Conservation Area, U.S Bureau of Land Management. Field studies were conducted as part of the 2003 Boise State University archaeological field school at Celebration Park at 10-CN-6 (the "One Eyed Lizard Site"). Regional geological and paleontological studies were carried out from 2003-2006.

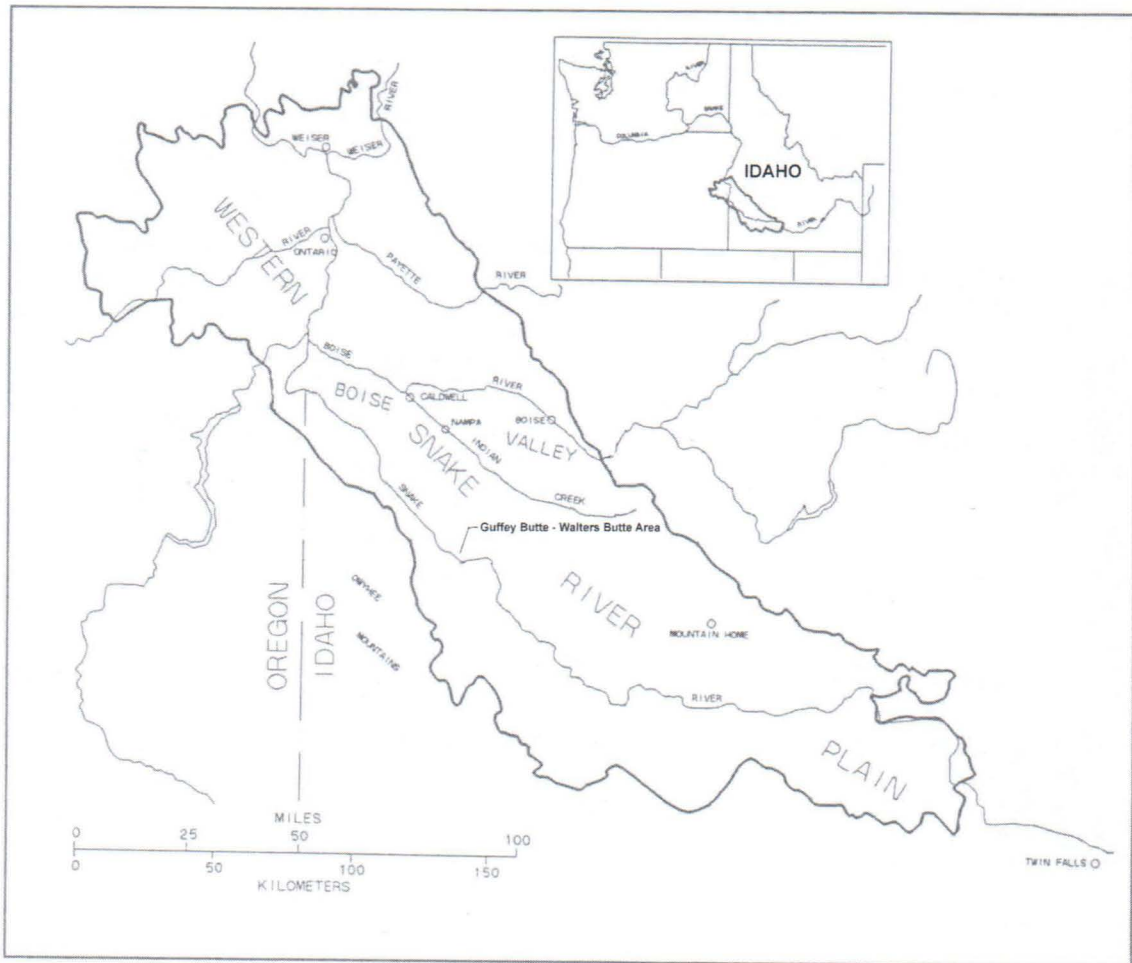


Figure 1. Location map. Base map from Othberg 1994.



## Geologic Description

The geologic units in the vicinity of Walters and Guffey Buttes consist of late Cenozoic (Tertiary and Quaternary) sediments and igneous rocks. The oldest deposits are sediments of the Glenns Ferry

Formation. These sediments are overlain by a series of Pleistocene volcanic lava flows and related igneous rock and land features. There are several sets of sedimentary units that were deposited during the Pleistocene and the Holocene (Table 1).

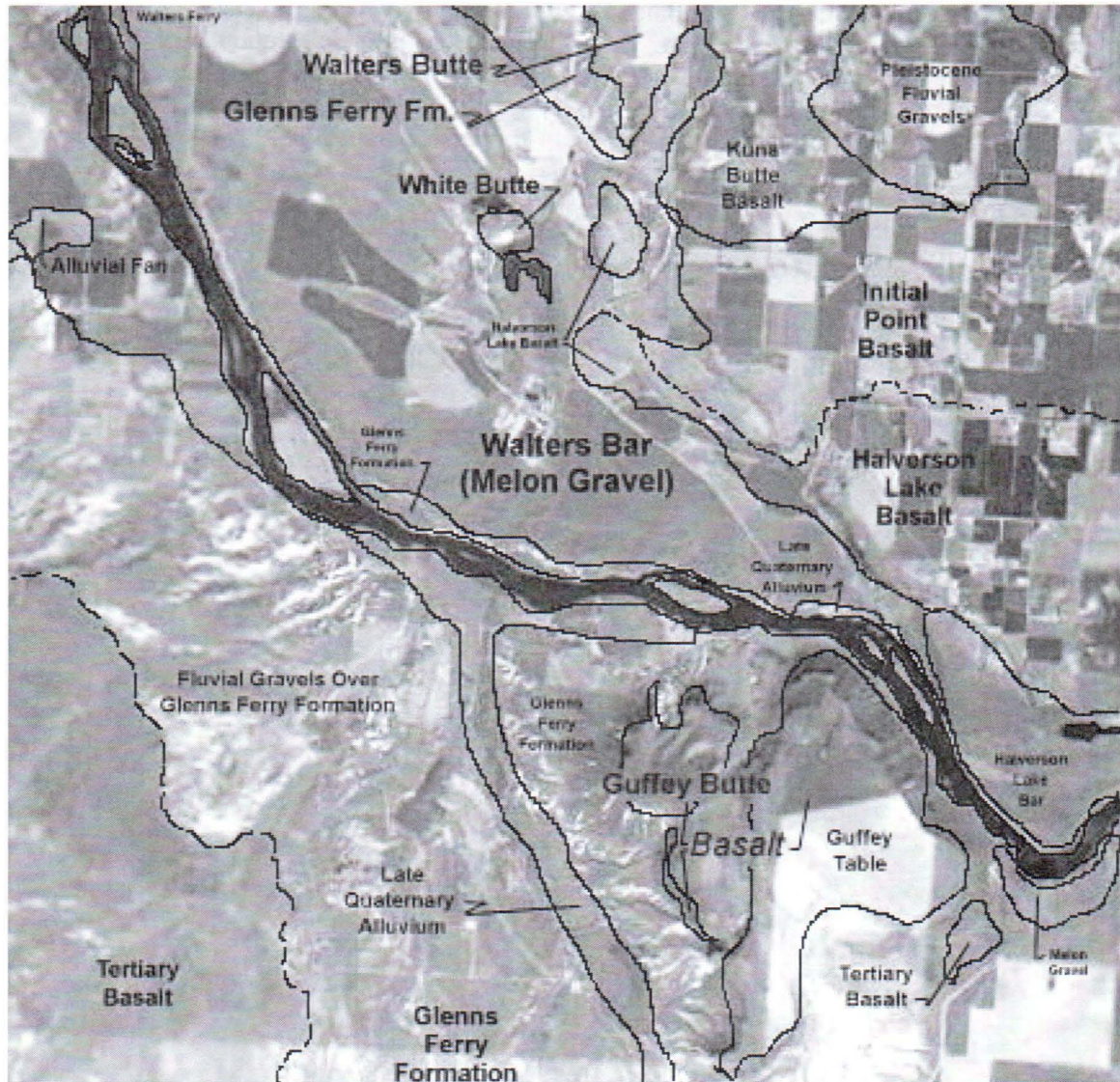


Figure 2. Generalized geologic map in the Walters Butte-Guffey Butte Region.



**TABLE 1. Geologic Units in the Walters Butte-Guffey Butte Region**

Unit	Description	Age
Late Quaternary Alluvium	Stream deposits with some eolian sediments, Holocene soils. Includes alluvium along Rabbit Creek, One Eyed Lizard Terrace	Late Quaternary (Late Pleistocene and Holocene)
Melon Gravel	Fluvial sediments (Bonneville flood deposits)	Late Pleistocene
High Gravels	Fluvial sediments	Middle-Late Pleistocene?
Initial Point Basalt	Lava flow	Middle Pleistocene
Halverson Lake Basalt	Lava flow	Middle Pleistocene
Kuna Butte Basalt	Lava flow	Middle Pleistocene
Walters Butte, Guffey Butte and Table Basalt	Lava flows and related igneous rocks	Lower Pleistocene
Bruneau Formation Sediments	Gravels and sands	Pleistocene
Guffey Railroad Bridge Basalt	Lava flows and related igneous rocks	Pliocene
Glenns Ferry Formation Sediments (Idaho Group)	Lacustrine and fluvial silts and sands, some gravels, some tephra	Pliocene and Early Pleistocene (= Plio-Pleistocene)

Badlands to the south of the Snake River are composed of fluvial and lacustrine sediments assigned to the upper Pliocene and lower Pleistocene Glenns Ferry Formation (Figures 2 and 3). The formation is composed of tephra, tuffaceous sand, silt and clay. These deposits contain Blancan and Irvingtonian fossils (Sankey 2002). The Glenns Ferry Formation contains yellow-tan unindurated silts easily eroded and retransported by the wind and water. In the vicinity of Guffey Butte and the adjacent mesa, the Glenns Ferry Formation contains the silts and clays are micaceous, while pebble gravels are dominated by rhyolite, basalt, and granite (cf. Watson 1999). Late Quaternary alluvial and eolian deposits in this area contain redeposited materials from the Glenns Ferry Formation. The Glenns Ferry Formation also contains several

Pliocene lava flows, such as the Guffey Butte Railroad Bridge basalt (Watson 1999; Bonnicksen and Godchaux 1998).

Sediments deposited after the Snake River became part of the Columbia River drainage are designated as part of the Bruneau Formation, while basalt flows younger than the Bruneau Formation are termed the Snake River Group (Malde and Powers 1962). The lava flow at Guffey Butte (Figures 2 and 4), is part of the Pleistocene Bruneau Formation (Malde 1989a); K-Ar measurements indicate an age of slightly older than 1 million years ago (Ma) (Table 2). The Glenns Ferry-Bruneau contact is estimated to date to slightly older than 1.77 Ma (Sankey 2002).



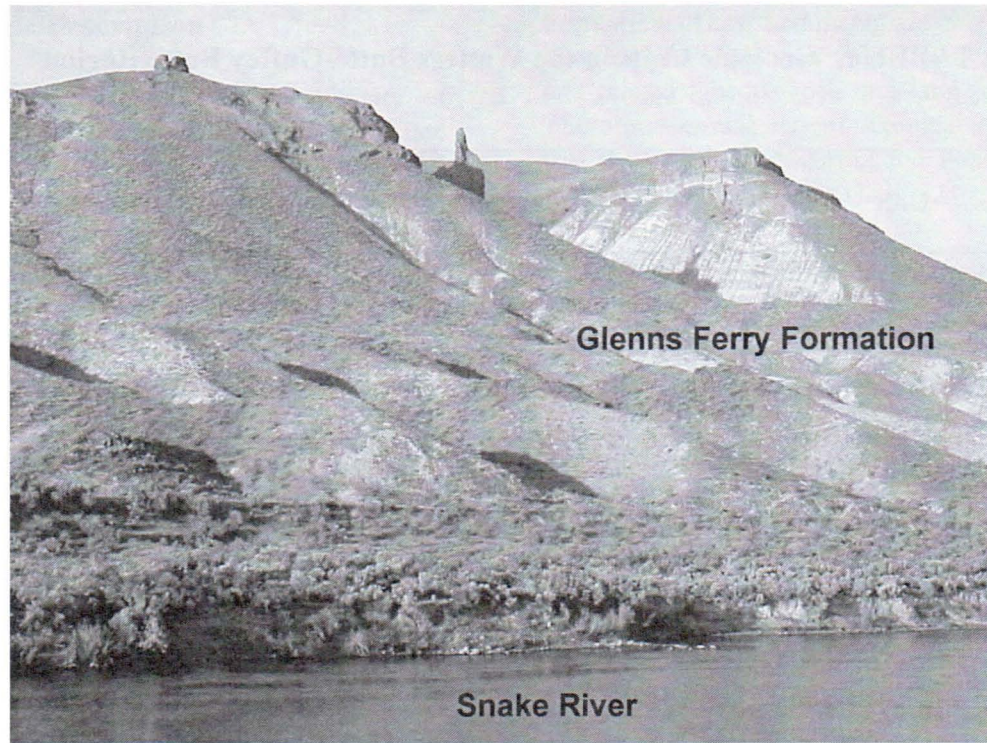


Figure 3. Glenns Ferry Formation adjacent to Guffey Butte. View looking south from the north bank of the Snake River.

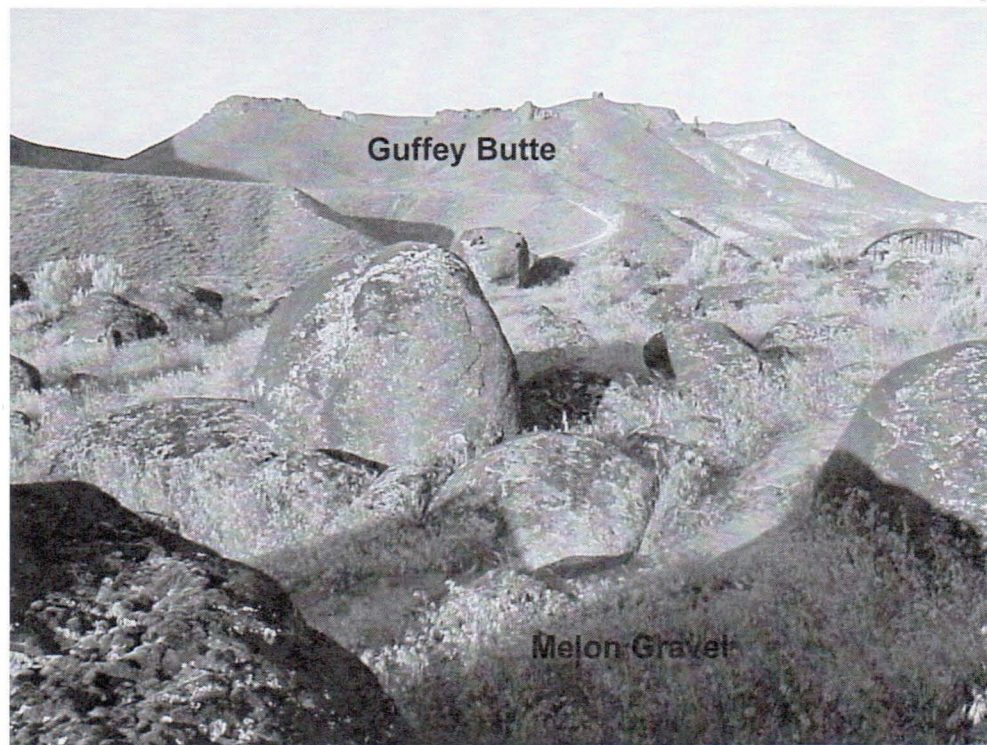


Figure 4. View towards Guffey Butte, south of Snake River. Sediments of the Glenns Ferry Formation are overlain by basalts at Guffey Butte. Note the Guffey Butte railroad bridge to the west and boulders of the Melon Gravel at Walters Bar in the foreground.



TABLE 2. Radiometric Ages

Location	Description	Age Measurement (Ma = million years; radiocarbon ages are uncalibrated years before present)	Method, Reference
Guffey Butte basalt	Bruneau Formation	1.04 +/- 0.07 Ma (79H10-7)	K-Ar, Malde 1989b; Malde 1991
Guffey Butte basalt	Bruneau Formation	1.09 +/-0.06 Ma (79H10-1)	K-Ar, Malde 1989b
Kuna Butte basalt	Snake River Group	0.387 +/- 0.31 Ma	K-Ar, Othberg et al. 1995
Initial Point basalt	Snake River Group	0.414 +/- 0.37 Ma	K-Ar, Othberg et al. 1995
Murphey's Rockshelter	Sediment	10,230 +/- 120	<sup>14</sup> C, Henry 1984
Murphey's Rockshelter	Sediment	8,740 +/- 110	<sup>14</sup> C, Henry 1984
Murphey's Rockshelter	Sediment	8,600 +/- 110	<sup>14</sup> C, Henry 1984
Murphey's Rockshelter	Wood	8,310 +/- 480	<sup>14</sup> C, Henry 1984
Murphey's Rockshelter	Sediment	7,280 +/- 110	<sup>14</sup> C, Henry 1984
Murphey's Rockshelter	Charcoal	6,350 +/-110	<sup>14</sup> C, Henry 1984
Murphey's Rockshelter	Charcoal	5,670 +/-110	<sup>14</sup> C, Henry 1984
Murphey's Rockshelter	Charcoal	3,210 +/- 70	<sup>14</sup> C, Henry 1984
Murphey's Rockshelter	Wood	1,050 +/- 60	<sup>14</sup> C, Henry 1984
Boulder Pit, 10-CN-9, Halverson Lake Bar, layer 5	Shell	9,900 +/- 120 (WSU-3780)	<sup>14</sup> C, Willig 1989
Boulder Pit, 10-CN-9, Halverson Lake Bar, layer 5	Shell	9,400 +/- 120 (WSU-3772)	<sup>14</sup> C, Willig 1989
Boulder Pit, 10-CN-9, Halverson Lake Bar, layer 4	Charcoal	1,610 +/- 180 (WSU-3771)	<sup>14</sup> C, Willig 1989
Boulder Pit, 10-CN-9, Halverson Lake Bar, layer 4	Charcoal	1,250 +/- 180 (WSU-3379)	<sup>14</sup> C, Willig 1989
Boulder Pit, 10-CN-9, Halverson Lake Bar, layer 3	Charcoal	1,050 +/- 190 (WSU- 3778)	<sup>14</sup> C, Willig 1989
Midden Site, 10-AA-306, Halverson Lake Bar, layer 5	Charcoal	1,770 +/- 70 (WSU- 3777)	<sup>14</sup> C, Willig 1989
Midden Site, 10-AA-306, Halverson Lake Bar, layer 4	Shell	3,300 +/- 105 (WSU- 3776)	<sup>14</sup> C, Willig 1989
Midden Site, 10-AA-306, Halverson Lake Bar, layer 3	Charcoal	270 +/- 70 (WSU- 3775)	<sup>14</sup> C, Willig 1989
Tree Site, 10-AA-169, Halverson Lake, layer 4	Hearth charcoal	1,000 +/- 70 (WSU- 3770)	<sup>14</sup> C, Willig 1989
10-CN-6, Feature cut	Charred material	620 +/- 40 (Beta-197310)	<sup>14</sup> C, Plew et al., this volume
Pre-Bonneville soil	Charcoal	15,250 +/- 160 (Beta- 23174, ETH-3518)	<sup>14</sup> C, Oviatt et al. 1992
Bonneville shoreline, Stockton Bar	Tufa	14,730 +/- 100 (SI- 4227C)	<sup>14</sup> C, Oviatt et al. 1992
Tabernacle Hill basalt flow	Tufa	14,320 +/- 90 (Beta- 238030)	<sup>14</sup> C, Oviatt et al. 1992
Melon Gravel boulder, Hagerman, Idaho	Organic matter on boulder	14,050 +/- 130 (AA- 2316)	<sup>14</sup> C, Oviatt et al. 1992
Deposit above Melon Gravel, Buhl, Idaho	Bone stratigraphically above Melon Gravel	10,675 +/- 95 (Beta- 43055, ETH-7729)	<sup>14</sup> C, Green et al. 1998



Basalt lava flows from Guffey Butte also have been mapped north of the Snake River (Malde 1989a). They are probably about the same age as basalt at Walters Butte (Figure 2). The Guffey Butte basalt is younger than a series of sedimentary deposits that lie below the lava flow and other igneous materials. Most of these sediments are lacustrine and fluvial facies of the Glens Ferry Formation, although there are also lake beds directly below the Guffey Butte basalt designated as deposits of the Bruneau Formation (Malde 1989a). A collection of early Pleistocene (Bruneau Formation) fish were recovered from Guffey Butte including *Mylopharodon hagermanensis*, *Gila milleri*, *Ptychocheilus arciferus*, *Acrocheilus latus*, *Italurus vespertinus*, *Archoplites taylori* (Smith et al. 1982).

Most of the basalt directly to the north of the Snake River (Figure 2) is part of the Pleistocene Snake River Group (Table 2). There are several named basalts formed by lava flows, including the Kuna Butte, Halverson Lake, and Initial Point basalts. Based on K-Ar measurements these are probably Middle Pleistocene (Table 2).

There are a series of sedimentary units that appear to have been deposited after the last local Middle Pleistocene igneous events. These deposits include high terrace gravels overlying sediment of the Glens Ferry Formation west of Guffey Butte, and also high gravels in the region east of Walters Butte (Figure 2). There are also large boulders and gravels composed of basalt (the Melon Gravel), and younger alluvial deposits that are mostly Holocene in age (Figure 2).

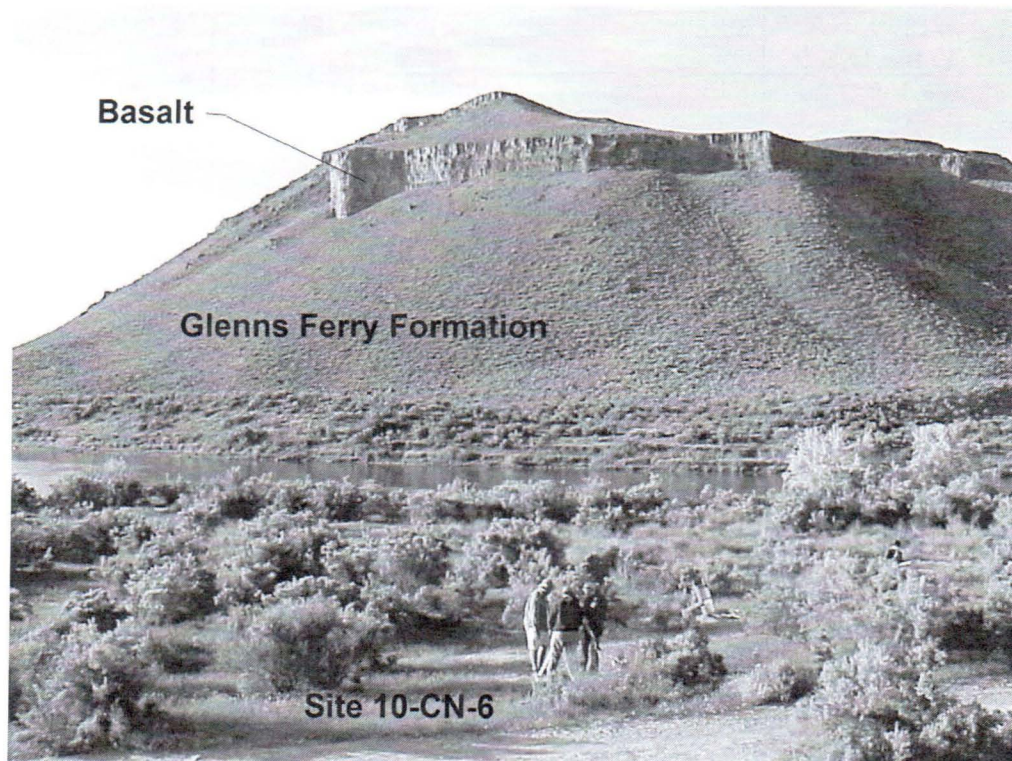


Figure 5. The basalt lava flows of Guffey Butte and Guffey Table are above Pleistocene lake deposits. The K-Ar sample locality 79H10 (Table 2) is on the edge of the basalt rim. Samples of tephra, diatoms, and fish remains were collected from this stratigraphic section (Smith 1982, Malde 1989a). View looks south from Walters Bar across One Eyed Lizard Terrace (10-CN-6 in foreground). The Snake River is in front of mesa ("Guffey Table"), which is formed of basalt.



The basalt boulders and gravels have been designated as the Melon Gravel, which is part of the Snake River Group (Malde 1968; Malde 1989a). The age of the Melon Gravel has been determined based on the ages of the Bonneville and Provo levels of Lake Bonneville (Table 2). Lake Bonneville appears to have reached its maximum elevation around 15,000 B.P. (uncalibrated radiocarbon years before present). The Bonneville shoreline complex appears to have formed until about 14,500 B.P. Sometime after the formation of the shoreline, the lake drained north into the Snake River, depositing the Melon Gravel. The lake level dropped and stabilized at the Provo level. The minimum age for the Melon Gravel is also constrained by radiocarbon dated organic matter collected from the surface of boulders deposited by the Bonneville Flood (Table 2).

Melon Gravel deposits locally consist of large boulder fields and sands and gravels composed of basalt. There is a large boulder field designated as the Walters Bar north of the Snake River between Guffey Butte and Walters Butte (Figure 2). This bar extends westward past Walters Ferry (Highway 45) and overlies Pliocene sediments of the Glens Ferry Formation. The boulders have diameters of over 3 m (about 10 feet) and are subrounded to well-rounded. Upstream, smaller bars are found along the north side of the Snake River in the vicinity of Halverson Lake and Initial Point (Figure 2). Sand deposits help to estimate the spatial

extent of the flood; road cuts and other exposures exhibit crossbedded basalt sand of the Melon Gravel. The flood waters appear to have surrounded but not covered Walters Butte (2,940 feet above sea level). Guffey Butte was also nearly encircled by flood waters but not covered.

There are Late Quaternary alluvial fan and stream deposits west of Guffey Butte and also terrace deposits in some places along the Snake River. These deposits in some instances overlie the Melon Gravel. They are thus younger than about 14,500 B.P. and have the potential to contain Late Pleistocene and Holocene artifacts. Generally they appear to consist of redeposited sediments derived from the Glens Ferry Formation.

The One Eyed Lizard Terrace contains the artifact assemblages from 10-CN-6. The deposits overlie boulders of the Gravel Melon. Stratigraphic sequences were exposed along the north bank of the Snake River and in excavations conducted by the Boise State University field school (Figures 7-9). The deposits are over 2 m thick adjacent to Snake River and decrease in thickness towards the north. Several stratigraphic zones are present, although the deposits consist chiefly of sands and silts (Figures 10 and 11). The terrace contains archaeological materials; a radiocarbon age for the upper part of the sequence is late Holocene (about 620 years B.P., Table 2).



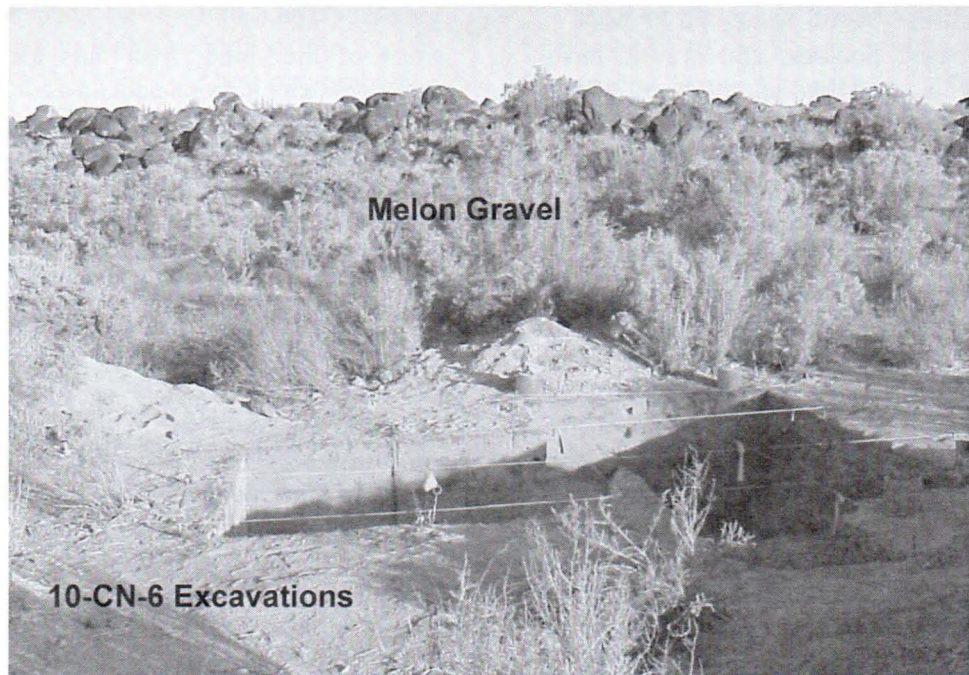


Figure 6. View looking west from One Eyed Lizard Terrace towards Melon Gravel of Walters Bar.

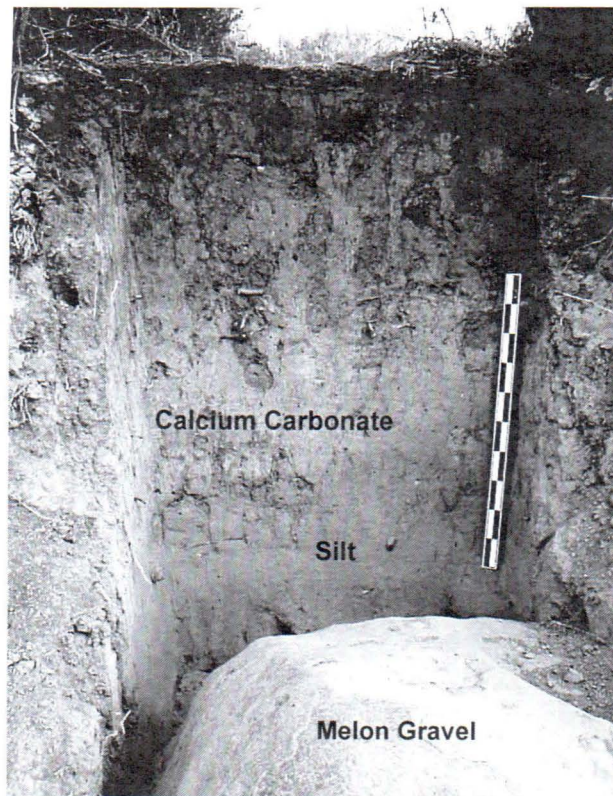


Figure 7. Aggradational sequence above Melon Gravel along edge of Snake River, One Eyed Lizard Terrace. Scale is 1 m.





Figure 8. Aggradational sequence forming One Eyed Lizard Terrace at 10-CN-6. These deposits overlie boulders of the Melon Gravel. Note cemented calcareous zone and incipient A horizons with sequence. The sequence is dominated by fine sands and silts. Scale is 1 m.

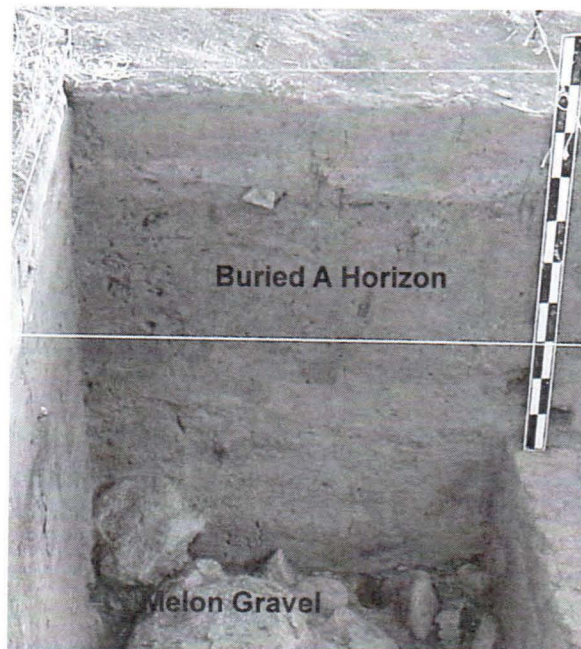


Figure 9. Aggradational sequence of One Eyed Lizard Terrace at 10-CN-6. Fine sands and silts overlie Melon Gravel. Scale is 1 m.

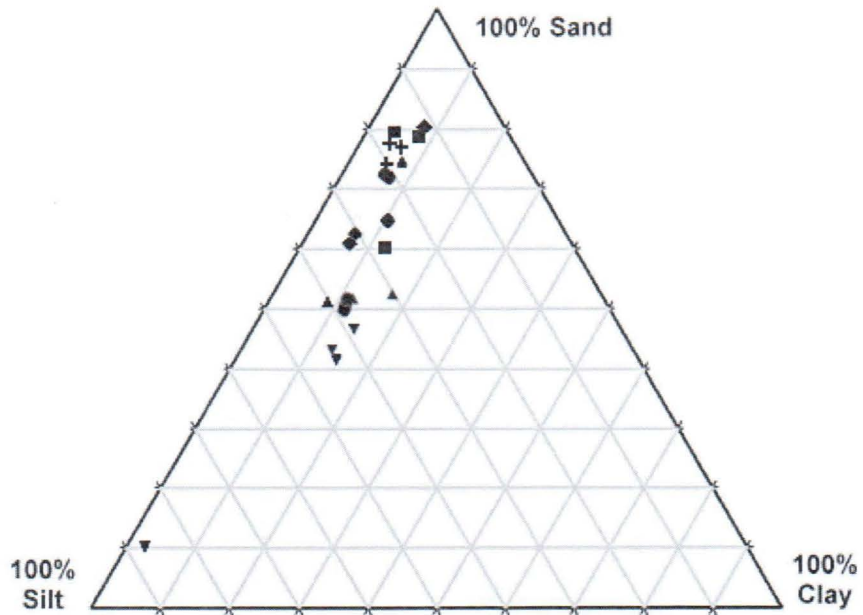


Figure 10. Tertiary diagram of sediments from the One Eyed Lizard Terrace. See Jacobs 2006 (this volume).

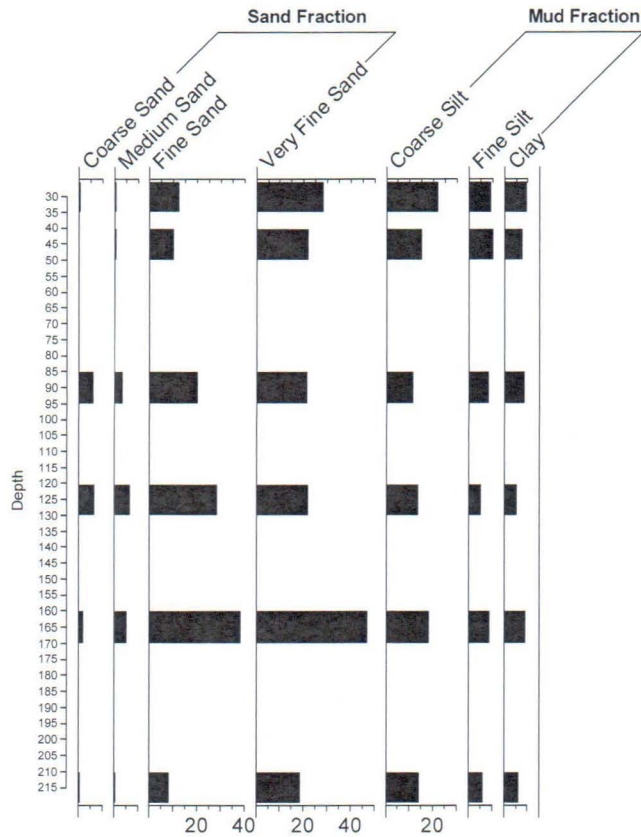


Figure 11. Sediment size fractions from aggradational sequence of One Eyed Lizard Terrace (see Jacobs 2006, this volume). Deposits lie above Melon Gravel.



The age of the aggradational sequence that forms the One Eyed Lizard Terrace is constrained by the Melon Gravel and potential time indicators within the sequence. If the deposits represented continuous aggradation without any episodes of erosion, the sediments and soils that form the terrace might be expected to contain evidence of climate change, environmental change or geologic events associated with the Late Pleistocene (including the Younger Dryas chronozone) and the Holocene.

Pollen from the Murphey's Rockshelter, situated in the Birds of Prey Conservation Area but upstream from the Walters Butte quadrangle, implies cool and moist climate from about 10,350-9,900 B.P. followed by an interval from 9,250-6,250 B.P. with warmer and climate conditions (Henry 1984). Late Holocene climates have generally been cooler and/or moister than the xeric interval from 9,250-6,250 B.P. (Henry 1984). Significantly warmer and drier conditions also prevailed in the McCall area of west-central, Idaho from about 9,750 to 3,200 B.P. (Doerner and Carrara 2001); the maximum aridity occurred after the deposition of the Mazama tephra (ca. 6,370 B.P.). These data suggest that the presence of regional arid climates during the middle Holocene that would be expected to form buried calcic zones within aggradational terraces. Besides buried zones of secondary carbonate within the terrace sequence, calcareous deposits have formed on the surface of boulders of the Melon Gravel (Figure 12).

Another potential time-marker is the Mazama tephra. It has been identified upstream from the Walters-Guffey Butte region at the Schellbach Cave and perhaps also downstream from Guffey Butte, just north of Walters Ferry (Figure 2) on Highway 45 (Statham and Wilson 1973). Near Walters Ferry there is an exposure at Grouch drain gully with a tephra buried 170 cm below the surface. At Schellbach Cave the volcanic ash is about 5-8 cm thick.

Immediately upstream from the One Eyed Lizard Terrace at Halverson Bar (Figures 2), the Boulder Pit Site (10-CN-9) contains a redeposited tephra that may be the Mazama ash in deposits overlying the Melon Gravel (Willig 1989). No distinct tephra layer was observed within the stratigraphic exposures at One Eyed Lizard Terrace.



Figure 12. Carbonate deposits coating the undersides of boulders of Melon Gravel. This is from a road cut within Walters Bar, north of the Guffey Butte railroad bridge.

Besides the stratigraphic sequence that forms the One Eyed Lizard Terrace, sedimentary sequences from the Halverson Bar area (upstream from the One Eyed Lizard Terrace) and deposits downstream from the Guffey Butte railroad bridge provide evidence for depositional settings along this region of the western Snake River Plain. At Halverson Bar, the Boulder Pit Site (10-CN-9) consists of deposits overlying boulders of the Melon Gravel (Willig 1989). This terrace sequence appears to contain alluvial and colluvial sediments as well as buried soils. These are associated with three radiocarbon measurements on charcoal, indicating late Holocene deposition (Table 2). Two radiocarbon measurements on molluscs might suggest the presence of early Holocene deposits, although radiocarbon measurements on shells appear to be older than measurements based on charcoal (Table 2). The Midden Site (10-AA-306) also contains fluvial sands and silts and colluvium (Willig 1989). The



sequence is late Holocene based on radiocarbon ages on shells and charcoal (Table 2). Charcoal from a hearth at the nearby Tree Site (10-AA-169) dated to the late Holocene overlies alluvium with interbedded lenses of gravel (Willig 1989). Fluvial and eolian deposits are also found at the Berm Site (10-AA-176) in the Halverson Bar area (Willig 1989).

Downstream from the One Eyed Lizard Terrace—west of the Guffey Butte railroad bridge and within the area of Walters Bar—a 1.8 m sedimentary sequence was recorded at Site 10-CN-1 (Sayer et al. 1997). The lowest deposit consists of fine sand with some gravel. Overlying deposits consist of sandy silt and silt and zones of secondary carbonate. This sequence has been interpreted as reflecting alluvial and eolian depositional events.

## Landscape Evolution

The geologic units can be used to interpret late Cenozoic events within the Walters-Guffey Butte area and adjoining regions of the Western Snake River Plain. Regionally, Lake Idaho—a late Cenozoic lake system—is represented by the Miocene Chalk Hills and the Plio-Pleistocene Glens Ferry Formation (Wood 2004). These deposits fill a downfaulted basin that is bounded to the south by the Owyhee Mountains granite and to the north by the granitoid rocks of the Idaho batholith. The Froman Ferry local fauna near Marsing downstream from the Walters-Guffey Butte region (Repenning et al. 1995), the Tyson Ranch local fauna just north of Sinker Creek (Sankey 2002), and vertebrate localities on the south side of the Snake River upstream from Celebration Park in the vicinity of



Figure 13. Glens Ferry Formation overlain by Gravel Melon at Walters Bar, west of 10-CN-6.



Wild Horse Butte and Jackass Butte (Shotwell 1970) are within the Glens Ferry Formation.

To the north, between Walters Ferry and Boise, the Glens Ferry Formation is eroded by granitic alluvium designated as the Tenmile Gravel (cf. Malde 1989b). The lithologic source of the alluvium is the Idaho batholith. Upstream towards Hagerman and south of the Snake River the Glens Ferry Formation is overlain by the Tuana Gravel (Malde and Powers 1962). The Tenmile Gravel and Tuana Gravel may be about the same age (Bliss and Moyle 2001).

Entrenchment of the Boise and Snake Rivers led to the deposition of the Bruneau Formation (Malde and Powers 1962). This represents the beginning of a drainage connection with the Columbia River, perhaps through Hell's Canyon. South of the Snake River, vertebrate fossils have been recovered from deposits of the Bruneau Formation at the Tyson Ranch and Three Mile East localities (Sankey 2002). The Bruneau Formation is associated with a series of ancestral canyons of the Snake River. The formation is dominated by fine-grained lake beds and stream deposits with some pebble gravel (Malde and Power 1962). These canyons were filled with basalt and lake-related deposits during the Pleistocene. Around 1 million years ago lava from Guffey Butte filled one of the ancestral canyons. After this event, the Pleistocene Snake River appears to have flowed in the presently upland region between Walters Ferry north to Nampa (Malde 1989b).

About 4 miles south of Murphy on Highway 45, gravels at 3,200 feet above sea level form a pediment; these have been designated as the Black Mesa Gravel (Middle Pleistocene) (Malde and Williams 1975). The Black Mesa Gravel is the youngest formation of the Idaho Group and is composed of gravels derived from the Bruneau Formation and Tuana Gravels. In

some places outcrops of the Black Mesa Gravel are capped by a caliche layer (Bliss and Moyle 2001).

Eruptions from Kuna Butte and Initial Point appear to have produced the lava which fills the present canyon south of Melba (Snake River Group basalt) (Malde 1989b). These appear to record Middle Pleistocene igneous activity within this region of the Snake River Plain.

Near the end of the Pleistocene, the landscape within this part of the Snake River Plain was significantly changed by erosion and deposition associated with the Bonneville Flood, dated to around 14,500 B.P. (Table 2). The basalt rim of the canyon was overtopped by the Bonneville Flood at about 290 feet above the present river (2545 feet above sea level). Downstream from Guffey Butte the canyon widens to form Walters Basin (Figures 14 and 15). Basalt was eroded from the narrow canyon upstream. After being confined within the canyon, the flood waters spread outward into Walters Basin, leading to a decrease in velocity and transport energy and the deposition of Melon Gravel (Malde 1989b; O'Conner 1993). The bar of Melon Gravel is 210 feet above the river (2460 feet above sea level). The maximum flood stage is recorded south of Melba by gravels. Further downstream, slackwater sediments of the flood overlie the Wilder and Whitney (Middle Pleistocene?) terraces west of Caldwell. Some Whitney terrace deposits are covered by 1-2 m of loess. Gravels of the younger (Late Pleistocene) Boise terrace also appear to have eroded and then been covered by the Bonneville Flood downstream from Caldwell. Sediments of the Melon Gravel contain Rancholabrean fossils (cf. Jefferson et al. 2002). Upstream from Caldwell the Boise terrace surface is capped by a thin deposit of loess (Othberg and Stanford 1992, Othberg 1994).



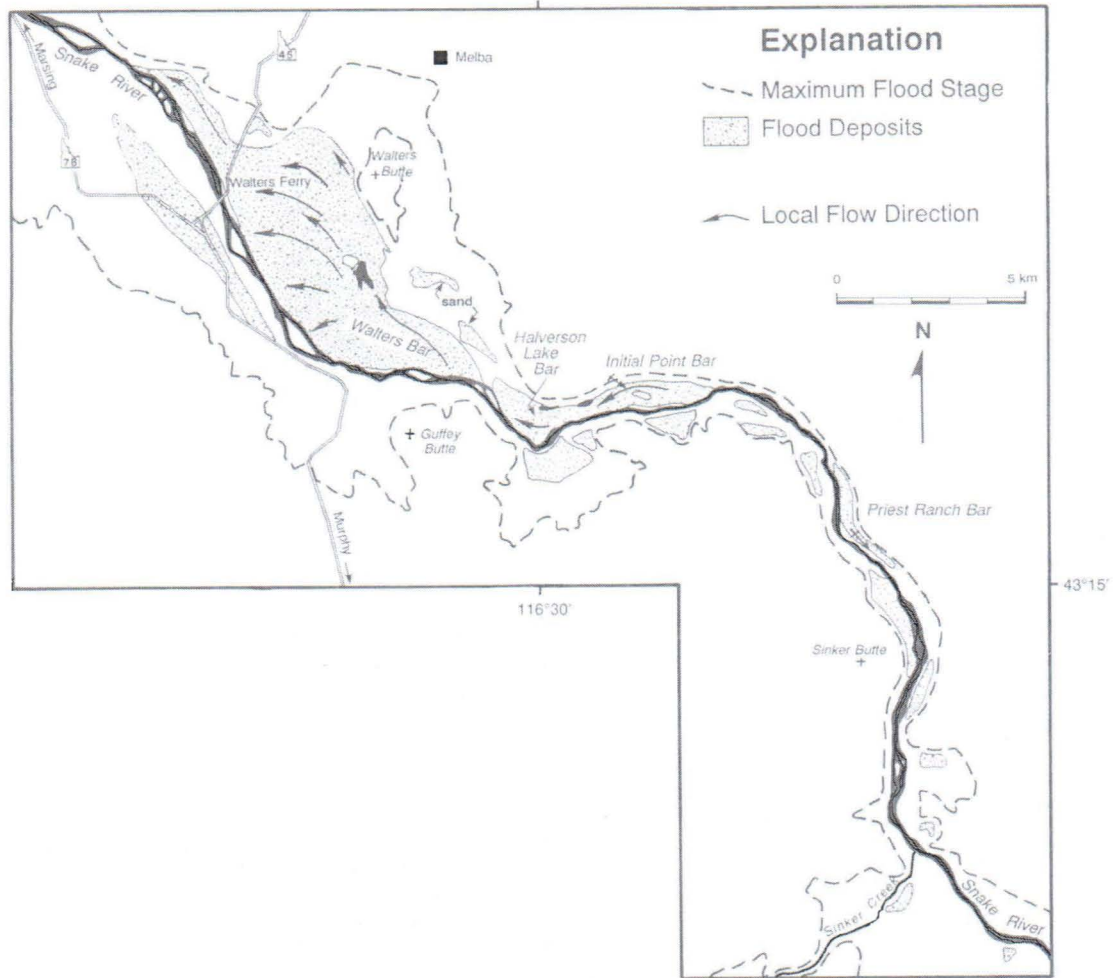


Figure 14. Maximum flood stage and location of flood deposits from Sinker Creek to Walters Ferry. Higher terrace deposits of an earlier Snake River have been found outside the distribution of Bonneville flood deposits north of the Snake River and west of Idaho Highway 45. Simplified from O'Conner 1993.

The One Eyed Lizard Terrace is an aggradational land feature dating to the Late Quaternary. The maximum potential age for deposits within the sequence is about 14,500 B.P. (uncalibrated radiocarbon years), based on underlying boulders of the Melon Gravel (Table 2). Despite possible occurrences of the Mazama tephra upstream and downstream from the terrace (Statham and

Wilson 1973, Willig 1989), no distinct layer of tephra was observed within the terrace. Buried zones of calcium carbonate could reflect regional Middle Holocene climate conditions associated with the Altithermal. Radiocarbon ages of charcoal recovered from the sedimentary deposits within Halverson Lake Bar (Figure 15) imply late Holocene aggradation.





Figure 15. Air photograph showing Guffey Table, basalts, river islands, Melon Gravel (Walters Bar and Halverson Lake Bar) and One Eyed Lizard Terrace.

These data can be compared to other indications of regional geomorphic events associated with the Snake River. Extensive reaches of the Snake River Plain are characterized by a very narrow floodplain and have been essentially static both laterally and vertically since the Bonneville Flood (Osterkamp 1998). For instance, fluvial islands downstream from Swan Falls consist of up to 2 m of slackwater deposits that show little signs of being eroded or overtopped by floods (Osterkamp 1998). The slackwater deposits consist of fine sand and silt on coarse flood debris. This type of fluvial activity contrasts with evidence of lateral migration of the Snake River near the

confluence with the Boise River, downstream from the Guffey Butte region. Upstream from Guffey Butte, near the town of Buhl, a local terrace sequence consists of Melon Gravel deposits overlain by eolian sands and silts, colluvium, and a buried soil (Green et al. 1998). At some locations the Melon Gravel are coated with secondary carbonates. Bone stratigraphically above the Melon Gravel was dated to about 10,675 B.P. (Table 2). The overlying sequence contains several erosional unconformities; one of these is associated with a truncated buried B horizon (Green et al. 1998).



## Summary

In the vicinity of Walters Butte and Guffey Butte, there are Pliocene, Pleistocene, and Holocene geologic units. These are composed of sediments and igneous rocks. Based on K-Ar measurements (Table 2), the igneous rocks reflect a series of eruption and lava flow events dated to the early and middle Pleistocene. The oldest sediments are associated with the fossil-bearing Glens Ferry and Bruneau Formations. Deposits associated with the Bonneville Flood, designated as the Melon Gravel, form the Halverson Lake Bars and Walters Bars (Figure 15). These record a major erosional and depositional event dated to about 14,500 B.P. (Table 2).

Stratigraphic sequences at the One Eyed Lizard Terrace and immediately upstream at Halverson Lake Bar contain charcoal dated to the late Holocene (Table 2). The present-day landscape in the Walters Butte and Guffey Butte region is the result of Late Tertiary and Quaternary sedimentary and igneous events.

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