JOURNAL OF THE IDAHO ACADEMY OF SCIENCE
VOLUME 32, ISSUE 1/2, JUNE/DECEMBER 1996

VERTEBRATE PALEONTOLOGY AND MAGNETOSTRATIGRAPHY OF THE UPPER GLENNS FERRY (LATEST PLIOCENE) AND LOWER BRUNEAU (PLIOCENE-PLEISTOCENE) FORMATIONS NEAR MURPHY, SOUTHWESTERN IDAHO

JULIA T. SANKEY[1]

ABSTRACT—Sedimentary deposits of the upper Glenns Ferry Formation near Murphy, Idaho contain the Tyson Ranch local fauna, a late Blancan V Land Mammal "Age" fauna, intermediate in age between the Grand View (Blancan V) and Froman Ferry (latest Blancan V-earliest Irvingtonian) local faunas. Many of the fossils from the Tyson Ranch local fauna represent stratigraphic range extensions into the upper Glenns Ferry Formation. Some of the taxa found, such as the cricetid rodent, *Mimomys (Ophiomys) parvus*, are more derived than those from the older Grand View local fauna. The upper Glenns Ferry Formation deposits are of normal polarity and correlate best to the upper Olduvai subchron of the Matuyama chron (latest Pliocene, older than 1.77 million years ago [Ma]). Overlying deposits of the lower Bruneau Formation produced fewer vertebrate fossils, but most of these are new records for the Bruneau Formation. The lower Bruneau Formation deposits in this area contain a short normal polarity and a long reversed polarity and correlate best to the uppermost Olduvai subchron and to the reversal above the Olduvai. Thus, near Murphy, the Glenns Ferry-Bruneau Formational contact is latest Pliocene (older than 1.77 Ma) and the lower Bruneau Formation contains the Pliocene-Pleistocene boundary (1.77 Ma).

Sankey, J.T. 1996. Vertebrate paleontology and magnetostratigraphy of the upper Glenns Ferry (latest Pliocene) and lower Bruneau (Pliocene-Pleistocene) formations near Murphy, southwestern Idaho. Journal of the Idaho Academy of Science 32.1/2:71-88.

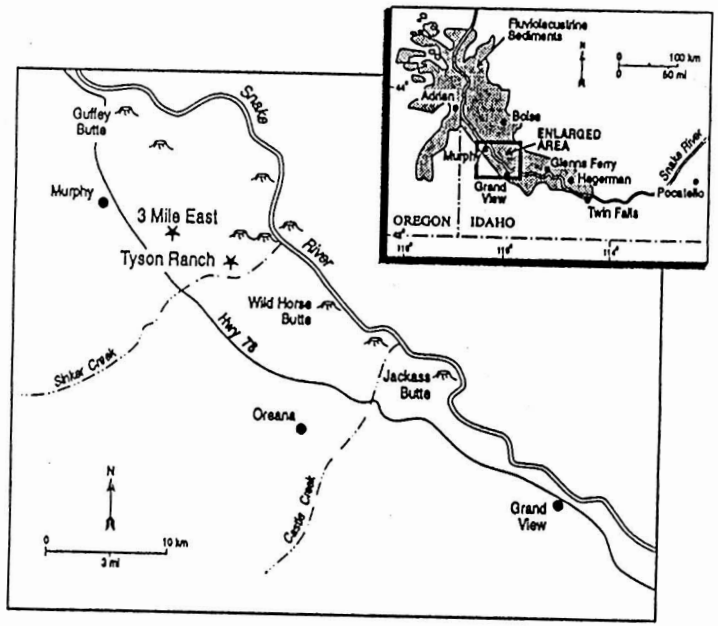
Keywords—Blancan, Irvingtonian, Land Mammal "Age", Pliocene, Pleistocene, paleontology, vertebrate, fossils, magnetostratigraphy, Glenns Ferry Formation, Bruneau Formation, Idaho, geology.

INTRODUCTION

Thick sedimentary deposits of the Glenns Ferry Formation in southern Idaho contain good sequences of vertebrate fossil faunas ranging in age from middle Pliocene through earliest Pleistocene (Figs. 1 and 2, Zakrzewski 1969, Bjork 1970, Neville *et al.* 1979, Conrad 1980, Shotwell 1970, Smith *et al.* 1982,

[1] Museum of Natural Science and Department of Geology and Geophysics, Louisiana State University, Baton Rouge, LA 70803, E-mail: jsankey@unix1.sncc.lsu.edu

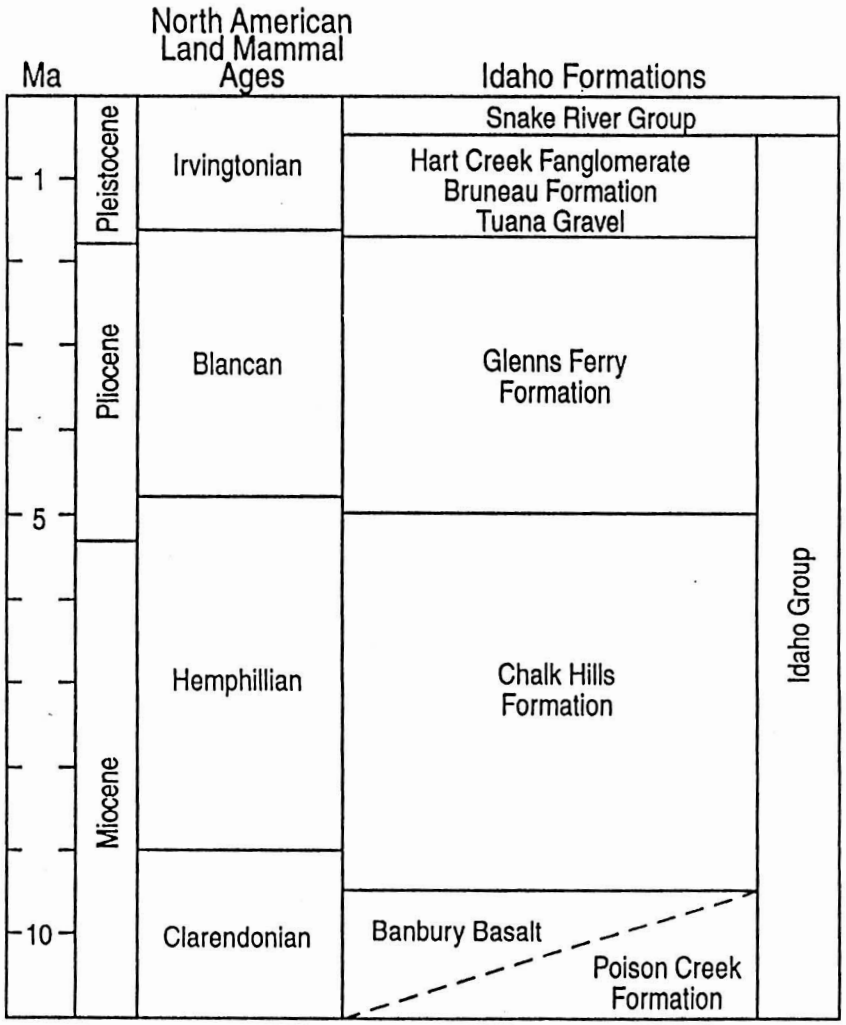
Figure 1. Field areas, shown by star, Western Snake River Plain, southwestern Idaho (Idaho map modified from Kimmel 1982, Middleton *et al.* 1985).



Repenning *et al.* 1995, McDonald *et al.* 1996). Glenns Ferry Formation deposits decrease in age to the northwest and toward the center of the Western Snake River Plain. The oldest and most intensely collected vertebrate fauna from the Glenns Ferry Formation is the Hagerman local fauna (Blancan II Land Mammal Age [LMA]) near the town of Hagerman in southern Idaho (Gazin 1936, Hibbard and Zakrzewski 1967, Zakrzewski 1969, Bjork 1970, Hibbard and Bjork 1971, McDonald *et al.* 1996). The youngest fauna from the Glenns Ferry Formation is the Froman Ferry local fauna (latest Blancan V-earliest Irvingtonian) near Marsing in southwestern Idaho (Repenning *et al.* 1995). Other local faunas exist intermediate in age between the Hagerman and Froman Ferry local faunas such as the Sand Point (Smith *et al.* 1982), Flat Iron Butte (Conrad 1980), Birch Creek (Hearst 1995, Repenning *et al.* 1995) and Grand View local faunas (Conrad 1980, Repenning *et al.* 1995). However, good age control exists for only the Hagerman, Sand Point, Grand View and Froman Ferry local faunas (Neville *et al.* 1979, Conrad 1980, Repenning *et al.* 1995, McDonald *et al.* 1996).

Sankey (1991) collected and described the Tyson Ranch local fauna, a newly discovered late Blancan V vertebrate fauna from uppermost Glenns Ferry Formation deposits in two areas near Murphy, southwestern Idaho (Table 1; Figs. 1, 3 and 4). The age of the fauna is tightly constrained by paleomagnetic determinations of deposits from the upper Glenns Ferry and lower Bruneau Formations (Fig. 5). The Tyson Ranch local fauna fills a gap which previously existed in the late Blancan vertebrate record of Idaho between the Grand View and Froman Ferry local faunas. The paleomagnetic work also provides new information on

Figure 2. Generalized stratigraphy of the Idaho Group (modified from Malde 1981).



the age of the Tyson Ranch local fauna and on the upper Glenns Ferry and lower Bruneau Formations near Murphy.

The poorly dated and less fossiliferous Bruneau Formation overlies the Glenns Ferry Formation (Fig. 2). Sankey (1991) collected and described vertebrate fossils from lowermost Bruneau Formation deposits stratigraphically above the Tyson Ranch local fauna (Table 1; Figs 3 and 4). Several of these vertebrates are new records for the Bruneau Formation. Prior to Sankey (1991) no

Table 1. Late Blancan V vertebrate fossils from the upper Glenns Ferry (UGF) and lower Bruneau (LB) Formations of the Tyson Ranch and Three Mile East areas (see Fig. 5 for stratigraphy and Sankey [1991] for fossil descriptions and IMNH localities). X presence, — absence, cf. most comparable taxon.

Taxon	*Tyson Ranch* UGF	LB	*Three Mile East* UGF	LB
Class Pisces				
Family Salmonidae				
Rhabdofario lacustris Cope				
Lake Trout	X	—	—	—
Family Cyprinidae				
Ptychocheilus arciferus (Cope)				
Squawfish	X	—	—	—
Acrocheilus latus (Cope)				
Chiselmouth	X	—	X	—
Mylocheilus robustus (Leidy)				
Shell-crushing minnow	X	—	—	—
Gila milleri (Smith)				
Miller's chub	—	—	X	—
Family Ictaluridae				
Ictalurus vespertinus Miller and Smith				
Catfish	X	—	X	—
Class Amphibia				
Family Ambystomatidae				
Ambystoma sp.				
Salamander	X	—	X	—
Family Pelobatidae				
Scaphiopus sp.				
Spadefoot toad	X	—	—	—
Family Bufonidae				
Bufo sp.				
True toad	X	—	X	—
Family Ranidae				
Rana sp.				
True frog	—	—	X	—
Class Reptilia				
Family Iguanidae				
cf. *Sceloporus* or *Uma*				
Spiny or Fringe-toed lizard	—	—	X	—
Family Colubridae				
cf. *Coluber*				
Racer	X	—	—	—
cf. *Lampropeltis*				
Kingsnake	X	—	X	—

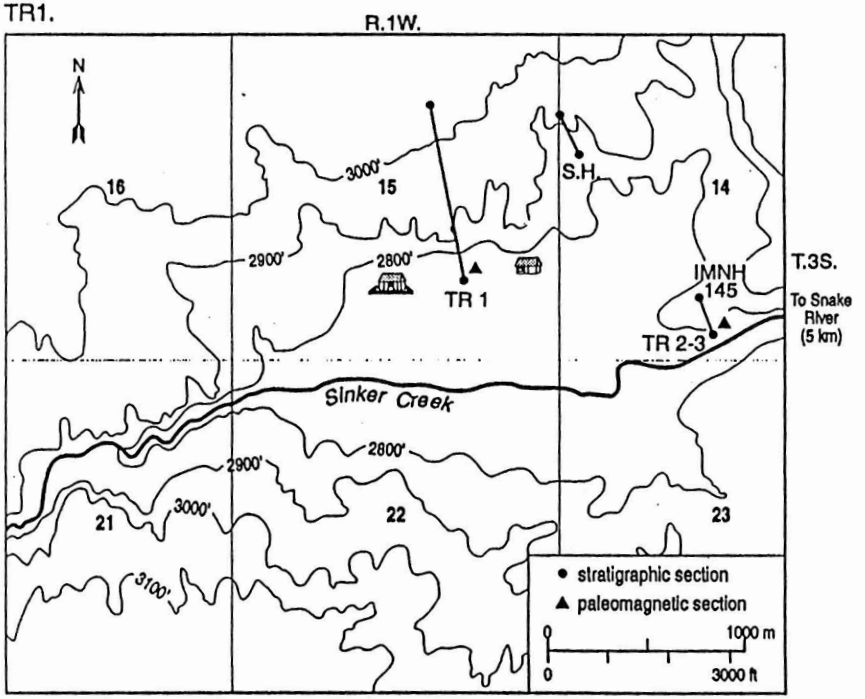
Table 1 continued

Taxon	*Tyson Ranch* UGF	LB	*Three Mile East* UGF	LB
cf. *Pituophis*				
Gopher snake	X	—	—	—
cf. *Thamnophis*				
Garter snake	X	—	X	—
Class Aves				
Family Anatidae				
Chen sp.				
Goose	X	—	—	—
Anas sp.				
Duck	—	—	X	—
Aix sponsa				
Wood duck	X	—	—	—
Class Mammalia				
Family Megalonychidae				
Megalonyx cf. *M. leptostomus* Cope				
Narrow-mouthed ground sloth	X	—	—	—
Family Mylodontidae				
Paramylodon harlani (Owen)				
Harlan's ground sloth	X	X	X	—
Family Mustelidae				
Taxidea taxus (Schreber)				
Badger	X	—	—	—
Satherium piscinarium (Leidy)				
Blancan otter	X	—	—	—
Family Canidae				
Canis lepophagus Johnston				
Johnston's coyote	X	—	—	X
Canis cf. *C. priscolatrans* Cope				
Wolf coyote	X	—	—	—
Family Felidae				
Felis lacustris Gazin				
Lake cat	X	—	—	—
Felis sp.				
Cat	X	—	—	—
Family Geomyidae				
Thomomys sp.				
Pocket gopher	X	—	X	—
Family Cricetidae				
Peromyscus sp.				
Mouse	—	—	X	—
Mimomys (Ophiomys) parvus Wilson				
	X	—	X	—

Table 1 continued

Taxon	*Tyson Ranch* UGF	LB	*Three Mile East* UGF	LB
Ondatra idahoensis (Wilson)				
Idaho muskrat	X	—	—	—
Mictomys vetus (Wilson)				
Old bog lemming	X	—	X	—
Family Leporidae				
Hypolagus sp.				
Rabbit	X	—	—	—
Sylvilagus sp.				
Cottontail rabbit	X	—	—	—
cf. *Lepus*				
Rabbit	X	—	—	—
Family Equidae				
Equus cf. E. simplicidens Cope				
American zebra	X	X	X	X
Family Tayassuidae				
Platygonus sp.				
Pearce's peccary	X	—	—	X
Family Camelidae				
cf. *Gigantocamelus*				
Giant camel	X	—	—	X
cf. *Camelops*				
Camel	X	—	—	X
cf. *Hemiauchenia*				
Llama	—	X	—	—
Family Cervidae				
Odocoileus sp.				
Deer	X	—	X	X
Cervus sp.				
Wapiti	X	X	—	—
Family Gomphotheriidae				
cf. *Stegomastodon*				
Stegomastodon	X	—	—	X

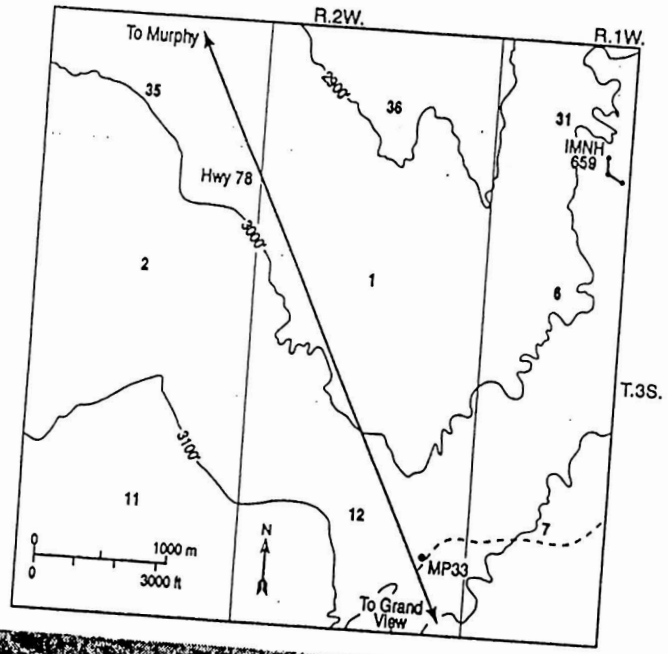
Figure 3. Tyson Ranch Area. Top: map with positions of the three measured sections (Sinker Butte 7.5' U.S.G.S. Quadrangle). Bottom: arrow to Red Trails Tuff at the Glenns Ferry-Bruneau Formational contact at measured section TR1.

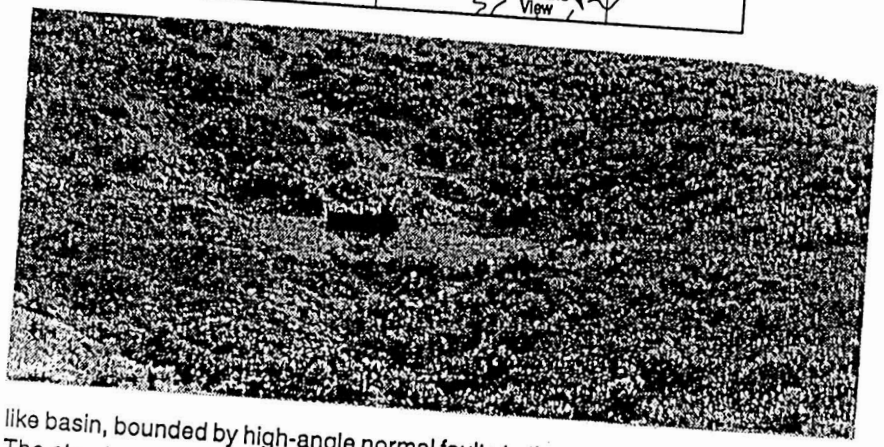


paleomagnetic analyses had been attempted on Bruneau Formation sedimentary deposits. This paleontologic and paleomagnetic work on the lower Bruneau Formation has constrained its age in one area of southern Idaho (Fig. 5).

GEOLOGIC HISTORY OF THE WESTERN SNAKE RIVER PLAIN

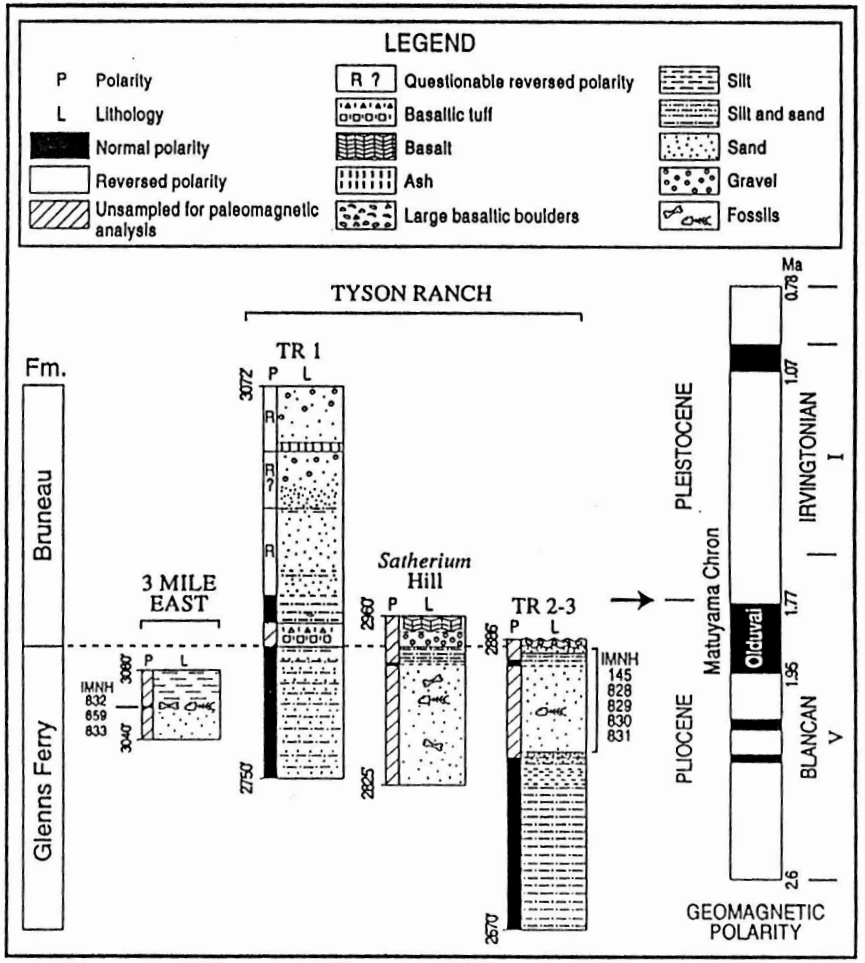
Figure 4. Three Mile East Area. Top: map with positions of measured section (Silver City 4 NE and Sinker Butte 7.5' U.S.G.S. Quadrangles). Bottom: arrow to Ground Sloth Locality, upper Glenns Ferry Formation.





like basin, bounded by high-angle normal faults to the north and south (Hill 1963). The structure was probably caused by rifting under extensional tectonic conditions (Zobak and Thompson 1978, Middleton *et al.* 1985). It was a down-dropping basin from Miocene to early Pleistocene, during which time it contained large lakes and associated floodplains and streams, which deposited thick sequences of sediments. These deposits are divided into four geologic formations of the Idaho Group, the Poison Creek, Chalk Hills, Glenns Ferry and Bruneau Formations (Fig. 2). These deposits decrease in age step-wise from the sides of

Figure 5. Glenns Ferry-Bruneau Formational boundary (dashed line) at four measured sections. Arrow indicates correlation to the upper Olduvai subchron of the geomagnetic polarity time scale (Berggren *et al.* 1995). Vertical scale is elevation.



the basin to the center and from the southeast to the northwest. The basin's shape changed through time, with the deepest part near the Idaho-Oregon border during the late Pliocene (Malde and Powers 1962, Middleton 1976, Middleton *et al.* 1985, Kimmel 1982, Smith *et al.* 1982, Swirydczuk *et al.* 1982, Malde 1991).

The Glenns Ferry Formation (Pliocene) includes more than 605 meters (m) of lacustrine, floodplain, and fluvial deposits representing about 2.5 million years. Its aerial extent is several thousand square kilometers (km), from south-central Idaho to south-eastern Oregon. It may represent either one large or several smaller coeval lakes. One large lake may have reached from south-central

Kimmel 1979, Conrad 1980, Jenks and Bonnichsen 1989). Alternatively, several, smaller, semi-contemporaneous lakes may have existed at progressively lower elevations in the basin. In either case, the basin was externally drained, first to the southwest into the Sacramento River of northern California and then to the northwest into the Columbia River of Washington (Wheeler and Cook 1954, Taylor 1960, Smith 1975, Conrad 1980, Smith *et al.* 1982, Malde 1991, Repenning *et al.* 1995). The ages for these different drainage paths is still unclear.

The overlying Bruneau Formation (latest Pliocene-Pleistocene) contains lacustrine, fluvial, and volcanic deposits (Amini *et al.* 1984, Malde 1991). The sedimentary deposits are canyon-filling units produced by damming of the ancestral Snake River by volcanic obstructions. The thickest parts of the formation occur near the present Snake River (Malde 1985, 1987, 1991).

The Tyson Ranch and Three Mile East areas near Murphy have deposits of the upper Glenns Ferry and lower Bruneau Formations (Figs. 1, 3 and 4) (Ekren *et al.* 1981, Malde 1989). However, Jenks and Bonnichsen (1990) and Jenks *et al.* (in prep.) mapped the sedimentary deposits in the two areas as "Idaho Group Undivided". I am following Malde's (1989) subdivision of the Idaho Group and the subdivision of the volcanic units by Jenks and Bonnichsen (1990) and Jenks *et al.* (in prep.).

METHODS AND MATERIALS

I constrained the age of the Glenns Ferry-Bruneau Formational contact near Murphy using paleontologic and paleomagnetic evidence from four stratigraphic sections in the two areas (Figs. 1, 3 and 4). For detailed descriptions of the geology, paleomagnetic analyses and fossils see Sankey (1991).

Four stratigraphic sections were measured and described and 125 paleomagnetic samples were collected and analyzed from the Tyson Ranch (Figs. 1, 3 and 5) and Three Mile East field areas (Figs. 1, 4 and 5). Oriented and carved samples of sediment were collected (the basalts and tuffs were not sampled). All paleomagnetic analyses were performed by the author at the U.S. Geological Survey Paleomagnetics Laboratory, Flagstaff, Arizona in 1989.

Most of the large vertebrate fossils were found by surface collecting. The small vertebrate fossils were found by surface collecting and by wet-screening sediment through 1.5 and 0.8 mm screens. This screened concentrate was then picked for fossils. Forty nine kilograms (kg) of screened concentrate was picked from localities at the top of Tyson Ranch section 2-3 (Figs. 3 and 5). Sixty six kg of screened concentrate was picked from localities at the Three Mile East section (Figs. 4 and 5). All fossils are curated and deposited in the Idaho Museum of Natural History (IMNH) Vertebrate Paleontology Collections, Pocatello, Idaho.

RESULTS AND DISCUSSION

STRATIGRAPHIC SECTIONS

Tyson Ranch 1 (TR1) is the thickest (98 m) and most complete section (Fig. 5). Upper Glenns Ferry Formation sediments of interbedded silts and very fine sands and abundant calcite-cemented, concretionary lenses of fine sands are 30.5 m thick at this section and directly underlie the Red Trails Tuff. The

Glenns Ferry-Bruneau Formational contact at TR1 is the base of the Red Trail Tuff (Fig. 5). The Red Trails Tuff is a ledge-forming unit with basaltic particles from sand to pebble size, is cross-bedded, displays cut and fill structures, and contains rip-up clasts of silt. It originated from the nearby Sinker Creek Butte or the Conservancy Flats Volcanoes (Jenks *et al.* in prep.) which are younger than 1.9 million years ago (Ma) (Amini *et al.* 1984). Overlying the Red Trails Tuff at TR1 are 41.1 m of lower Bruneau Formation deposits. This is a coarsening upward sequence of indistinctly bedded, very fine to coarse sand, some silt, and one diatomite bed (Fig. 5) mapped by Malde (1989) as upper lake beds of the Bruneau Formation (third canyon stage). The uppermost 18.9 m of TR1 contain a coarsening upward sequence of indistinctly bedded, unindurated, orange to brown sands and gravels, and one ash bed (undated) mapped by Malde (1989) as the Hart Creek fanglomerate (fourth canyon stage of the Bruneau Formation).

Tyson Ranch 2-3 (TR2-3) is a 65.6 meter-thick section through silt and sand of the upper Glenns Ferry Formation. Very fossiliferous sands were wet screened and picked for small vertebrate fossils between 856.5 and 874.2 m elevation at TR2-3 (Table 1; Figs. 3 and 5; IMNH localities 145, 828, 829, 830, and 831). The section is capped by basaltic boulders, probable erosional remnants of Sinker Butte Basalt. Sinker Butte Basalt overlies the Red Trails Tuff (Jenks *et al.* in prep.) and is younger than 1.5 Ma (Amini *et al.* 1984).

***Satherium* Hill** (SH) is an informal name for a small hill within Tyson Ranch named after the Blancan otter mandible found there (Figs. 3, 6B and 5). SH is 41.1 m of section through upper Glenns Ferry and lower Bruneau Formations. The lower 26.8 m contain interbedded silts and sands of the upper Glenns Ferry Formation (Malde 1989). The overlying 6.7 m of silt and sand are mapped as lower lake beds of the Bruneau Formation (third canyon stage, Malde 1989). The upper 1.3 m contain sand and gravel sized basaltic particles and the Red Trails Tuff (Jenks *et al.* in prep.).

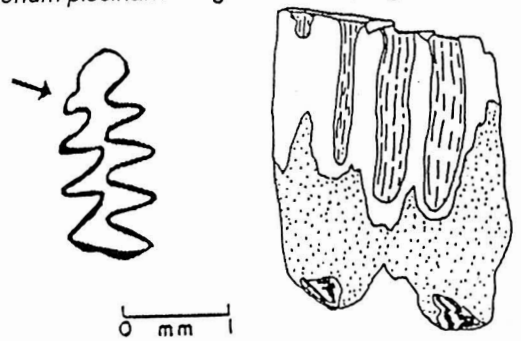
Three Mile East (TME) is an area of Glenns Ferry and Bruneau Formation outcrops 0.8 km to the northwest of Tyson Ranch (Figs. 1 and 4). A 12.2 m section of indistinctly bedded fossiliferous sands and silts was measured through the upper Glenns Ferry Formation. The fossils included a partial ground sloth skeleton (IMNH 39714) and many small vertebrate bones found by wet-screening and picking the sediments surrounding the sloth bones (IMNH localities 659, 832 and 833, Table 1, Figs. 4 and 5).

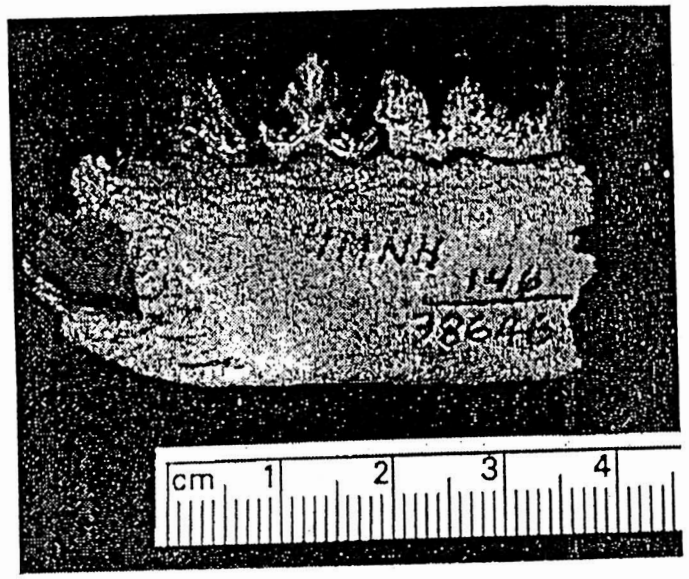
Fossils were also found 1 km south of this measured section from upper Glenns Ferry deposits below the Red Trails Tuff and from lower Bruneau Formation deposits above the Red Trails Tuff (Table 1). Outcrops of the Red Trails Tuff are not traceable between the Three Mile East and Tyson Ranch areas. However, the tuff at Three Mile East is referred to here as the Red Trails Tuff because it is very similar in appearance, elevation, and stratigraphic position to the Red Trails Tuff at Tyson Ranch.

INTERPRETATIONS OF PALEOENVIRONMENTS

Glenns Ferry Formation. The upper Glenns Ferry Formation deposits at Tyson Ranch and Three Mile East formed on a flood plain and are dominated by stream channel, overbank, and point bar deposits (Fig. 5). Channel deposits are characterized by fine to medium sand with numerous calcite-cemented, medium

Figure 6. A. *Mimomys* (*Ophiomys*) *parvus* lower left first molar, occlusal and labial views (IMNH 40325). Arrow to incipient sixth triangle. Enamel shown in black, dentine white, cementum hatchured, and dentine tracts stippled. B. *Satherium piscinarium* right mandible, lingual view (IMNH 38646).





sand lenses, and are more fossiliferous than the overbank deposits (IMNH localities in Figs. 3, 4 and 5). Channel deposits (stippled pattern in Fig. 5) occur within the Glenns Ferry Formation at the following sections: TR2-3, SH and Three Mile East. Over-bank and point bar deposits are characterized by interbedded silts and sands with numerous root casts but few fossils. Typical overbank deposits (dash-stippled pattern in Fig. 5) occur in the Glenns Ferry Formation at the following sections: TR1, TR2-3, SH and Three Mile East. During floodplain depo-

Bruneau Formation. The Red Trails Tuff, the water-laid, basaltic tuff of the lower Bruneau Formation, occurs in both field areas and is a good paleotopographic indicator for the area. For example, within Tyson Ranch it is thickest at TR1, where it apparently flowed into a paleolow. The lower Bruneau Formation deposits directly above the Red Trail Tuff at TR1 are a coarsening upward sequence of silty sands, sands and gravels, with one diatomite bed, one undated ash bed, and very few fossils. The capping gravels above the ash bed at TR1 are part of the Hart Creek fanglomerate and may represent channel deposits from a vigorous fluvial system (Malde 1987, 1989, 1991).

PALEOMAGNETISM AND MAGNETOSTRATIGRAPHY

Most of the samples displayed characteristic remanent magnetization (ChRM) which decays univectorially during alternating field demagnetization (AFD). The overprint of the present day magnetic field was usually erased at a peak field of 40 millaTessla during AFD. Most samples contained only two major components of magnetization. Some samples displayed a good polarity signal, but not a good direction. Other samples were viscous, and displayed erratic movement during AFD and did not have a ChRM. Samples from such sites, usually from sands without a fine-grained component, have been deleted. For a detailed description of the paleomagnetic analyses see Sankey (1991).

VERTEBRATE PALEONTOLOGY

A variety of vertebrate fossils were recovered and identified from the upper Glenns Ferry and lower Bruneau Formations at the Tyson Ranch and Three Mile East areas (Table 1). Most of these fossils are from the upper Glenns Ferry Formation, especially from screening sites in the channel sands. Vertebrate fossils are rare in the Bruneau compared to the Glenns Ferry Formation. Only isolated bones from large vertebrates were found. No screening sites for small vertebrates were located.

The vertebrates from the upper Glenns Ferry Formation at both Tyson Ranch and Three Mile East are referred to here as the Tyson Ranch local fauna because of their taxonomic similarity and their stratigraphic position within deposits of normal polarity (Olduvai subchron) from the upper Glenns Ferry Formation below the Red Trails Tuff. The Tyson Ranch local fauna vertebrates are characteristic of the late Blancan V (Kurten and Anderson 1980, Lundelius *et al.* 1987, Repenning 1987). The bog lemming, *Mictomys vetus* (Wilson), present in both areas, is a particularly good indicator species for Blancan V faunas (Repenning 1987). The Tyson Ranch local fauna is very similar to the Grand View local fauna from Jackass Butte (Blancan V, 2.4-2.0 Ma) (Conrad 1980, Repenning 1987), however, some of the taxa are slightly more derived in the Tyson Ranch local fauna. One example is the cricetid rodent, *Mimomys (O.) parvus* Wilson (Fig. 6A). In 50 lower first molars from the Tyson Ranch local fauna, the average dentine tract height is 0.73 millimeters (mm), higher than the average from 50 Grand View local fauna specimens (0.57 mm, n=50). Additionally, 38 % of these 50 lower first molars contain 1 to 3 incipient reentrants on the anterior cap (incipient sixth triangles, Fig. 6A). Conrad (1980) reports that only a small percentage of the Grand View specimens contain incipient triangles. Both of these evolutionary trends observed in the *Mimomys (O.) parvus* of the Tyson

Ranch local fauna (increase in dentine tract height and number of incipient sixth triangles in the lower first molars), were also observed in the older Grand View local fauna. The Tyson Ranch local fauna has also extended the stratigraphic range of many vertebrates into the upper Glenns Ferry Formation (Sankey 1991). Additionally, the partial ground sloth skeleton (*Paramylodon harlani*, IMNH 39714) from the Three Mile East Area is the most complete *Paramylodon* from the upper Glenns Ferry Formation (H.G. McDonald pers. comm. 1990).

Because so few vertebrate fossils were found from the lower Bruneau Formation at Tyson Ranch and Three Mile East they have not been assigned to a new local fauna. However, further vertebrate collections (especially of small mammals) may justify naming a new local fauna. From the present collection the following fossils are new records for the Bruneau Formation: *Paramylodon harlani* (Owen), *Canis lepophagus* Johnston, *Platygonus* sp., cf. *Gigantocamelus*, cf. *Camelops* and *Odocoileus* sp. (Table 1). All of these taxa occur in both Blancan and Irvingtonian faunas. Bruneau Formation deposits are above the Red Trail Tuff and are of normal polarity (uppermost Olduvai) and of reversed polarity (reversal above the Olduvai, Fig. 5). Based on the paleomagnetic interpretations, the vertebrate fossils from the lower Bruneau Formation are very latest Blancan V and the lower Bruneau Formation in this area contains the Pliocene-Pleistocene boundary (1.77 Ma, Berggren *et al.* 1995). Investigators who are interested in early Irvingtonian faunas should focus on locating good screening sites in the lower Bruneau Formation for recovery of small mammal fossils such as *Phenacomys grycli*, an early Irvingtonian indicator species (Repenning 1987).

Recognition of the Glenns Ferry-Bruneau Formational contact follows mapping by Malde (1989). Ages of the uppermost Glenns Ferry and lowermost Bruneau Formations in two areas near Murphy can be constrained using paleomagnetic and paleontologic evidence.

All four measured sections through deposits of the upper Glenns Ferry Formation are of normal polarity and correlate to the top of the Olduvai normal polarity subchron of the Matuyama chron (Fig. 5). This correlation is based on: 1) the characteristic late Blancan V Tyson Ranch local fauna, 2) the derived nature of some of the fossils from the Tyson Ranch local fauna compared to the pre-Olduvai (2.4-2.0 Ma, Conrad 1980) Grand View local fauna at Jackass Butte and 3) the ages of the overlying Red Trails Tuff (younger than 1.9 Ma, Amini *et al.* 1984) and Sinker Butte Basalt (younger than 1.5 Ma, Amini *et al.* 1984). Although the radiometric dates for the Red Trails Tuff and Sinker Butte Basalt have wide ranges, their oldest dates (1.9 and 1.5 Ma respectively, Amini *et al.* 1984) eliminate the possibility that the normal polarity zone correlates to anything prior to the Olduvai (1.95-1.77 Ma; Berggren *et al.* 1995) (Fig. 5). Lower Bruneau Formation deposits above the Red Trails Tuff at Tyson Ranch display a short normal and long reversed polarity zone and correlate to the Olduvai and the reversal above the Olduvai (Fig. 5). The Pliocene-Pleistocene boundary occurs at this polarity change (1.77 Ma, Berggren *et al.* 1995). The few vertebrate fossils from the lower Bruneau Formation are characteristic of late Blancan V faunas and do not help further refine the age.

Therefore, the Glenns Ferry-Bruneau Formational contact in this area is within the Olduvai. More precisely, the contact is probably within the upper part

of the Olduvai because of the reversed polarity deposits above the Red Trails Tuff.

The newly discovered and described Tyson Ranch local fauna (late Blancan V, upper Olduvai, Sankey 1991) from the upper Glenns Ferry Formation in two areas near Murphy has filled a gap in the Blancan fossil record of Idaho that existed between the Grand View (Blancan V, pre-Olduvai, Conrad 1980) and the Froman Ferry local faunas (latest Blancan V-earliest Irvingtonian, post-Olduvai, Repenning *et al.* 1995). Closely spaced paleomagnetic samples from the upper Glenns Ferry and lower Bruneau Formations has constrained the ages for these units in this area (Sankey 1991).

The upper Glenns Ferry Formation deposits are of normal polarity and correlate to the upper Olduvai subchron (younger than 1.77 Ma, Berggren *et al.* 1995) and contain the Tyson Ranch local fauna (Sankey 1991). The late Blancan V Tyson Ranch local fauna has extended the stratigraphic ranges of many taxa above the Grand View local fauna. Many of the Tyson Ranch local fauna taxa are more derived than those of the Grand View local fauna. The best example is the cricetid rodent, *Mimomys (O.) parvus*.

Most of the vertebrates from the lower Bruneau Formation near Murphy are new records for the formation. Additionally, Sankey (1991) reported the first paleomagnetic work on the Bruneau Formation sedimentary deposits. In this area they are within a short normal and long reversed polarity zone and correlate to the uppermost Olduvai and the reversed polarity zone above the Olduvai (Fig. 5). The Glenns Ferry-Bruneau Formational contact in this area is latest Pliocene (older than 1.77 Ma) and the lower Bruneau Formation contains the Pliocene-Pleistocene boundary (1.77 Ma).

ACKNOWLEDGMENTS

Many people provided assistance during this study, especially Pete Kaufman (summer, 1989) and Jean Sankey (summers 1986 and 1989). Illustrations were done by Emilee Mead and Robin O'Reiley (Northern Arizona University) and by Clifford Duplechin (Louisiana State University). Drafts of this paper were improved by William A. Akersten, Michael Woodburne, H. Gregory McDonald and Judith A. Schiebout. I also appreciate advice from Gary Calderone, Jim Mead, Charles Repenning and Ted Weasma. This work was financially supported by the U.S. Geological Survey (Flagstaff Field Station), Sigma Xi (Northern Arizona University chapter), and the Theodore Roosevelt Memorial Fund (American Museum of Natural History). Fossils were collected under permits from the Bureau of Land Management, Boise District Office. Special thanks are extended to the John Tyson family.

LITERATURE CITED

Amini, M.H., Mehnert, H.H. and Obradovich, J.D. 1984. K-AR ages of late Cenozoic basalts from the Western Snake River Plain, Idaho. Isochron/West 41:7-11.

Berggren, W.A., Kent, D.V., Swisher, III, C.C. and Aubry, M. 1995. A revised Cenozoic geochronology and chronostratigraphy. *In:* Berggren, W.A., Kent, D.V. and Hardenbol, J., Eds. Geochronology, Time Scales and Global Stratigraphic Correlations: A Unified Temporal Framework for an Historical Geology. Society of Economic Paleontologists and Mineralogists Special Volume, No. 54. 386 pp.

Bjork, P.R. 1970. The Carnivora of the Hagerman local fauna (Late Pliocene) of southwestern Idaho. Transactions American Philosophical Society, n.s. 60.7:1-54.

Conrad, G.S. 1980. The biostratigraphy and mammalian paleontology of the Glenns Ferry Formation from Hammett to Oreana, Idaho. Ph.D. dissertation, Idaho State University, 334 p.

Ekren, E.B., McIntyre, D.H. and Malde, H.E. 1981. Geologic Map of Owyhee County, Idaho, west of Longitude 116 W. U.S. Geological Survey Misc. Geologic Investigations Map I-1256.

Gazin, C.L. 1936. A study of the fossil horse remains from the upper Pliocene of Idaho. Proceedings, United States National Museum 83.2985:281-320.

Hearst, J.M. 1995. Geology of the Upper Poison Creek and Birch Creek Areas. Western Association of Vertebrate Paleontology Field Trip Guidebook, 1995 Meeting. Hagerman, Idaho. 154 pp.

Hibbard, C.W. and Bjork, P.R. 1971. The insectivores of the Hagerman local fauna, upper Pliocene of Idaho. Contributions, Museum of Paleontology, University of Michigan 23:171-180.

Hibbard, C.W. and Zakrzewski, R.J. 1967. Phyletic trends in the late Cenozoic microtine *Ophiomys* gen. nov., from Idaho. Contributions, Museum of Paleontology, University of Michigan 21:255-271.

Hill, D.P. 1963. Gravity and crustal structure in the western Snake River Plain, Idaho. Journal of Geophysical Research 68.20:5807-5819.

Jansen, E., Bleil, U., Henrich, R., Kringstad, L. and Slettemark, B. 1988. Paleoenvironmental changes in the Norwegian Sea and northeastern Atlantic during the last 2.8 m.y.-Deep Sea Drilling Program sites 610, 642, 643, and 644: Paleoceanography, v. 3:563-581.

Jenks, M.D. and Bonnichsen, B. 1989. Subaqueous basalt eruptions into Pliocene Lake Idaho, Snake River Plain, Idaho. pp. 17-34. *In:* Chamberlain, V.E., Breckenridge, R.M., and Bonnichsen, B., Eds. Guidebook to the Geology of Northern and Western Idaho and Surrounding Area. Idaho Geological Survey, Bulletin 28.

Jenks, M.D. and Bonnichsen, B. 1990. Geologic map of the Wild Horse Butte Quadrangle, Ada and Owyhee Counties, Idaho. Idaho Geological Survey, Technical Report 90-8. 9 pp.

Jenks, M.D., Bonnichsen, B. and Godchaux, M.M. In prep. Geologic map of the Sinker Butte Quadrangle, Owyhee County, Idaho. Idaho Geological Sur-

Kimmel, P.G. 1979. Stratigraphy and paleoenvironments of the Miocene Chalk Hills Formation and Pliocene Glenns Ferry Formation in the Western Snake River Plain, Idaho. Ph.D. dissertation, University of Michigan. 331 p.

Kimmel, P.G. 1982. Stratigraphy, age, and tectonic setting of the Miocene-Pliocene lacustrine sediments of the Western Snake River Plain, Oregon and Idaho. pp. 559-578. *In:* Bonnichsen, B. and Breckenridge, R. M., Eds. Cenozoic Geology of Idaho. Idaho Geological Survey, Bulletin 26.

Kurten, B. and Anderson, E. 1980. Pleistocene mammals of North America. Columbia University Press, New York. 443 pp.

Lundelius, E.L., Jr., Churcher, C.S., Downs, T., Harington, C.L., Lindsay, E.H., Schultz, G.E., Semken, H.A., Webb, S.D. and Zakrzewski, R.J. 1987. The North American Quaternary sequence. pp. 211-235. *In:* Woodburne, M.O., Ed. Cenozoic Mammals of North America. University of California Press, Berkeley. 336 pp.

Malde, H.E. 1985. Raft trip through the Snake River Birds of Prey Area to view canyon-filling volcanics and lake beds of the Pleistocene Snake River. Rocky Mountain Section of the Geological Society of America, Guide Book. 48 pp.

Malde, H.E. 1987. The Montini Volcano; A lava dam on the ancestral Snake River, southwest Idaho. pp. 127-130. *In:* Buess, S.S., Ed. Rocky Mountain Section of the Geological Society of America, Centennial Field Guide 2.

Malde, H.E. 1989. Geologic map of the Bruneau Formation in the Sinker Butte and Wild Horse Butte Quadrangles, southwestern Idaho. U.S. Geological Survey, Miscellaneous Field Studies Map MF-2063-B.

Malde, H.E. 1991. Quaternary geology and structural history of the Snake River Plain, Idaho and Oregon. pp. 251-281. *In:* Morrison, R.B., Ed. Quaternary Nonglacial Geology, Conterminous United States, The Geology of North America. Geological Society of America, Vol. K-2.

Malde, H.E. and Powers, H.A. 1962. Upper Cenozoic stratigraphy of the Western Snake River Plain, Idaho. Geological Society of America Bulletin 73:1197-1220.

McDonald, H.G., Link, P.K. and Lee, D.E. 1996. An overview of the geology and paleontology of the Pliocene Glenns Ferry Formation, Hagerman Fossil Beds National Monument. Northwest Geology 26:16-45.

Middleton, L.T. 1976. Depositional environments of the Glenns Ferry Formation near Jackass Butte, Idaho. M.S. thesis, Idaho State University, Pocatello. 59 pp.

Middleton, L.T., Porter, M.L. and Kimmel, P.G. 1985. Depositional settings of the Chalk Hills and Glenns Ferry Formations west of Bruneau, Idaho. pp. 37-53. *In:* Flores, R.M. and Kaplan, S.S., Eds. Cenozoic Paleogeography of West-Central United States. Rocky Mountain Section of the Society of Economic Paleontologists and Mineralogists.

Miller, R.R. and Smith, G.R. 1967. New fossil fishes from Pliocene-Pleistocene Lake Idaho. Occasional Papers, University of Michigan Museum of Zoology 654:1-24.

Neville, C., Opdyke, N.D., Lindsay, E.H. and Johnson, N.M. 1979. Magnetic stratigraphy of Pliocene deposits of the Glenns Ferry Formation, Idaho, and its implications for North American mammalian biostratigraphy. American Journal of Science 279:503-526.

Repenning, C.A. 1987. Biochronology of the microtine rodents of the United States. pp. 236-268. *In:* M.O. Woodburne, Ed. Cenozoic Mammals of North America, University of California Press, Berkeley.

Repenning, C.A., Weasma, T.R. and Scott, G.R. 1995. The Early Pleistocene (Latest Blancan-Earliest Irvingtonian) Froman Ferry Fauna and History of the Glenns Ferry Formation, Southwestern Idaho. U.S. Geological Survey Bulletin 2105. 86 p.

Sankey, J.T. 1991. A late Blancan-early Irvingtonian vertebrate fauna and magnetostratigraphy from the upper Glenns Ferry and lower Bruneau Formation, near Murphy, southwestern Idaho. M.S. thesis. Northern Arizona University. 206 p.

Shotwell, J.A. 1970. Pliocene mammals of southeast Oregon and adjacent Idaho. Bulletin, Museum of Natural History University of Oregon 17:1-103.

Smith, G.R. 1975. Fishes of the Pliocene Glenns Ferry Formation, southwest Idaho. Papers in Paleontology, Museum of Paleontology, University of Michigan 14:1-68.

Smith, G.R., Swirydczuk, K., Kimmel, P.G. and Wilkinson, B.H. 1982. Fish biostratigraphy of late Miocene to Pleistocene sediments of the Western Snake River Plain, Idaho. pp. 519-540. *In:* Bonnichsen, B. and Breckenridge, R.M., Eds. Cenozoic Geology of Idaho, Bulletin 26, Idaho Geological Survey, Moscow.

Swirydczuk, K., Larson, G.P. and Smith, G.R. 1982. Volcanic ash beds as stratigraphic markers in the Glenns Ferry and Chalk Hills Formations from Adrian, Oregon, to Bruneau, Idaho. pp. 543-558. *In:* Bonnichsen, B. and Breckenridge, R.M., Eds. Cenozoic Geology of Idaho, Bulletin 26, Idaho Geological Survey, Moscow.

Taylor, D.W. 1960. Distribution of the freshwater clam *Pisidium ultramontanum*; a zoogeographic inquiry. American Journal of Science 258:325-334.

Van Domelen, D.J. and Rieck, H.J. 1992. Paleomagnetic polarity of some vertebrate fossil localities of the Pliocene Glenns Ferry Formation in the Chalk Hills, near Froman Ferry, western Snake River Plain, southwest Idaho. U.S.G.S. Open File Report 92. 17 pp.

Wheeler, H.E. and Cook, E.F. 1954. Structural and stratigraphic significance of the Snake River capture, Idaho-Oregon. Journal of Geology 62:525-536.

Zakrzewski, J.R. 1969. The rodents from the Hagerman local fauna, upper Pliocene of Idaho. Contributions, Museum of Paleontology, University of Michigan 23:1-36.

Zobak, M.L. and Thompson, G.A. 1978. Basin and range rifting in northern Nevada: clues from a mid-Miocene rift and its subsequent offsets. Geology 6.2:111-116.