

**GEOLOGIC MAP OF LANDSLIDE AND OTHER CENOZOIC DEPOSITS
BIG SKY-MOONLIGHT BASIN-LOST LAKE AREA
MADISON RANGE, MONTANA**

Susan M. Vuke

Montana Bureau of Mines and Geology
Open-File Report 581

2009

Derived from Geologic map of the Fan Mountain, Lone Mountain, and Gallatin Peak 7.5' quadrangles, Madison and Gallatin Counties, Montana (Kellogg and Vuke, in review).

GEOLOGIC MAP OF LANDSLIDE AND OTHER CENOZOIC DEPOSITS
BIG-SKY-MOONLIGHT BASIN-LOST LAKE AREAS
MADISON RANGE, MONTANA

The geologic map of the Big Sky-Moonlight Basin-Lost Lake area is derived from a geologic map of the Fan Mountain, Lone Mountain, and Gallatin Peak 7.5' quadrangles (Kellogg and Vuke, in review) prepared to provide a 1:24,000-scale geologic map that transects the northern part of the north-trending Madison Range (Figure 1) through the STATEMAP component of the National Cooperative Geologic Mapping Program. The Montana Bureau of Mines and Geology STATEMAP Advisory Committee selected this area because it includes proposed development and ongoing development in two adjacent large ski resort areas, Moonlight Basin and Big Sky which include ski lifts, housing developments, business facilities, and golf courses. The focus of geologic mapping in this area was potential geologic hazards such as landslides and Cenozoic faults.

Laramide compression: Spanish Peaks fault and Hilgard thrust fault system

Laramide compressional deformation began about 79 million years ago in the northern Madison Range (Kellogg and Harlan, 2007). The Spanish Peaks fault (Figure 1) is a major basement-involved structural system that developed during Laramide contraction. It was reactivated along Precambrian planes of weakness in the Archean basement (Garihan and others, 1983). Offset on the fault is at least 10,000 feet (Garihan, and others, 1983) (3050 m) and may be as much as 13,500 feet (McMannis and Chadwick, 1964) (4115 m). Archean metasedimentary and meta-igneous rock (not shown on the map) occurs northeast of the fault. A band of footwall Cambrian through Cretaceous sedimentary rocks that strikes parallel to the fault, crops out along the southwest side of the fault. Beds in this area generally dip moderately to steeply to the southwest and are locally overturned. The Hilgard thrust fault system (Figure 1) also developed along the west side of the Madison Range during Laramide compression.

Dacite porphyry intrusion (post-compression)

Laramide compression ended by about 69 million years ago, before the end of the Cretaceous Period (Kellogg and Harlan, 2007). Lone Mountain is an intrusive center south of the Spanish Peaks fault in the map area. Similar centers immediately outside the map area include Fan Mountain, Cedar Mountain, and Pioneer Mountain (Figure 1). Gravity data suggest that Lone Mountain is the main intrusive center in the area, and that Fan, Cedar, and Pioneer Mountains are subsidiary centers (Tysdal and others, 1986). Numerous dacite porphyry sills characterize these mountains, with the thickest sills on Lone Mountain. Andesite mountain (a local name, not an official name of the U.S. Board of Geographic Names), east of Lone Mountain is probably also cored by thick sills from the Lone Mountain intrusive center.

Cenozoic extension: Madison Range fault system (post-intrusion)

Cenozoic extension began during the Eocene but accelerated during the Middle Miocene. Gravity and seismic data indicate that the west side of the Madison Range (west of the map area; Figure 1) is bounded by a large, steep, generally north-trending, west-dipping fault zone, the Madison Range fault system (Pardee, 1950) that developed during the Tertiary and is still active (Stickney and others, 2000). The faults of this system are interpreted as listric-normal, and many of the faults developed along fault planes of pre-existing, east-directed Laramide thrust faults in the Hilgard thrust system (Figure 1) (Kellogg and others, 1995).

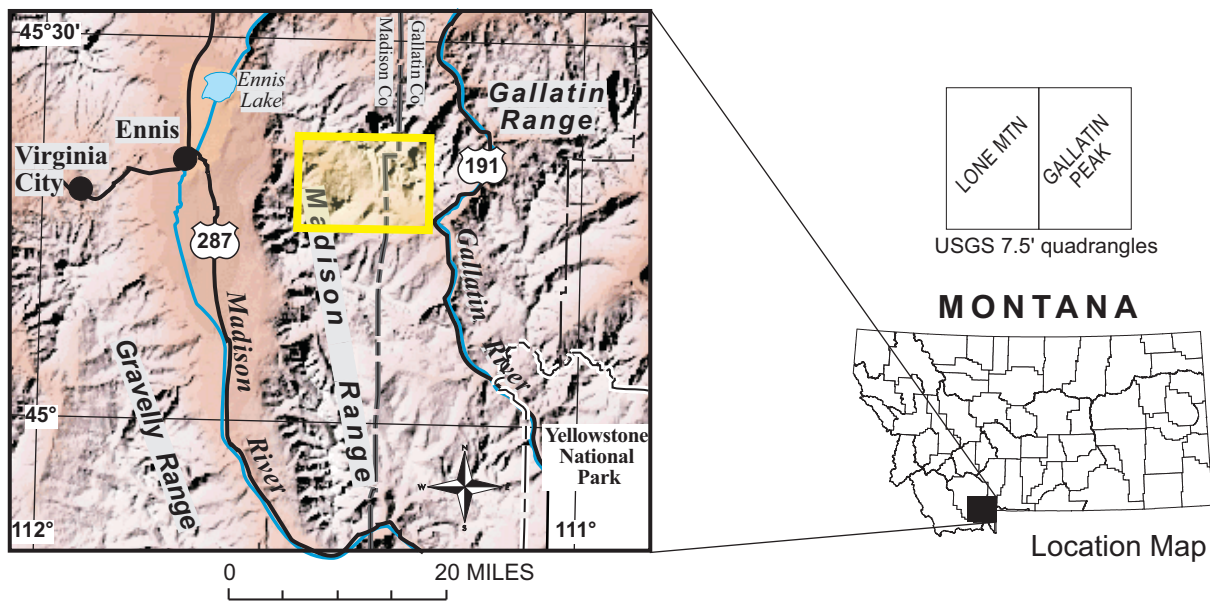
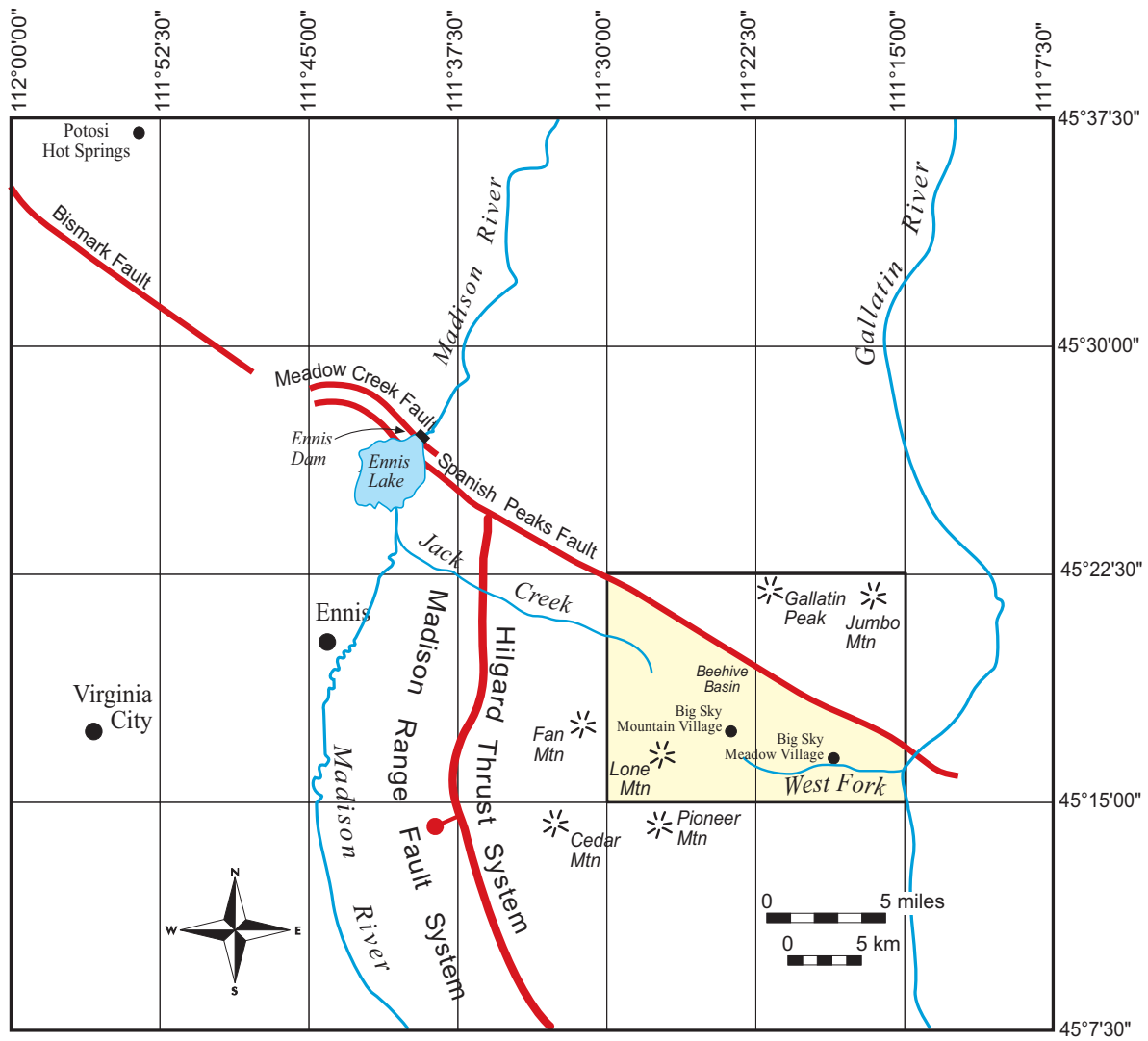


Figure 1. Location of the map area.

Landslide deposits

Landslide deposits were mapped in much of the map area. The steep slopes on the southwest side of the Spanish Peaks fault and on the flanks of Lone Mountain and adjacent mountains, coupled with moderately to steeply dipping sedimentary beds, provide a setting conducive to mass movement, particularly in the mudstone- and shale-rich Cretaceous sedimentary rocks that underlie much of the map area. Bentonitic mudstone in the Vaughn Member of the Mowry Formation, and bentonite beds in the Frontier Formation increase susceptibility of the Cretaceous units to mass movement.

In one area, multiple landslides moved the Cretaceous Kootenai Formation downslope from about ¼ mi (.4 km) below the Spanish Peaks fault to near the confluence of Moonlight Creek and Jack Creek, a distance of one mile (1½ km) from its source. The red mudstone and distinctive conglomerate and sandstone of the Kootenai Formation make it easier to distinguish in landslide deposits than the black shale and mudstone of younger Cretaceous units, which have probably also moved downslope a comparable distance in many places.

Geologic hazards

The map area is within the Intermountain seismic belt which is characterized by late Quaternary normal faulting, diffuse shallow seismicity, and episodic scarp-forming earthquakes of magnitude 6.5-7.5 (Smith and Arabasz, 1991). The largest historic earthquake in the northern Rocky Mountains occurred about thirty miles (50 km) south of the map area--the 1959 magnitude 7.3 Hebgen Lake earthquake (Witkind, 1960; Doser, 1985). The earthquake produced surface rupture along twenty-one miles (34 km) of the pre-existing Hebgen and Red Canyon faults (part of the Madison Range fault system), and it produced numerous smaller scarps in the area. It triggered the Madison Canyon slide, a 28-million cubic meter rockslide, the largest seismically triggered rockslide in North America during historic time. Twenty-eight people lost their lives (Hadley, 1964). In addition, a climber who signed the register on the summit of Granite Peak in the Beartooth Mountains the day before the Hebgen Lake earthquake, apparently fell to his death while descending, possibly as a result of the earthquake (*Bozeman Chronicle*, 2000).

The map area is about 25 miles (40 km) north of the Yellowstone region, the most seismically active part of the entire Intermountain seismic belt which extends from northern Arizona to northern Montana (Smith and Arabasz, 1991). The Centennial tectonic belt immediately west of the Yellowstone region is the most tectonically and seismically active part of the Northern Intermountain seismic belt. Northwest of the map area in the Three Forks Basin, seismicity has been common (Qamar and Hawley, 1979), and a significant earthquake swarm occurred near the town of Norris in the summer of 1987 (Stickney, 1988). Proximity to these seismically active areas places the map area within a zone of potential strong to very strong ground shaking that may occur or be exceeded at a specified probability of two percent in fifty years or one chance in 2500 on an annual basis (Wong and others, 2005, Plate 17).

A study of tree rings was conducted on trees tilted or damaged by landslides in the eastern Gravelly Range along the southern Madison Valley southwest of the map area (Carrara and O'Neill, 2003). Multiple periods of movement during the twentieth century were documented based on the

tree-ring patterns. A correlation was found between significant earthquakes (the 1983 Borah Peak, 1959 Hebgen Lake, 1935 Helena, 1925 Clarkston, and 1908 Virginia City earthquakes) and indications of landslide movement based on tree-ring indicators. The study suggests that many of the landslide movements were triggered by, or coincident with earthquakes as much as 200 km from the study area (125 miles). Tree-ring studies have not been conducted in the current map area, but landslide movement was presumably triggered by these earthquakes in the region as well, and will likely continue to be triggered by future large earthquakes.

Although the map area is within the Intermountain seismic belt, historic data indicate seismic quiescence in the map area (Wong and others, 2005, Plate 1). Areas with large Holocene faults, yet with modern seismic quiescence, are common in the Intermountain seismic belt (Smith and Sbar, 1974; Smith and Arabasz, 1991; Stickney, 2007). Extensional stress may be relieved in these areas by major earthquakes, whereas nearby areas without large faults may experience lesser magnitude, but more abundant seismicity (Stickney, 1995).

The Madison Range fault system west of the map area has also had less paleoseismic activity than along this fault system to the south. That may be because the southern area displacement occurs along a principal basement-involved normal fault whereas to the north in the map area, there are multiple normal faults that detach the hanging wall of older thrust faults. The individual shorter faults have less displacement (Ruleman and Lageson, 2002). Alternatively, the lesser amount of late Quaternary displacement northward along the Madison Range fault system may result from its greater distance from the Yellowstone volcano-tectonic province (M. Stickney, written communication, 2009).

Even without a seismic trigger, the potential for landslide movement is high in the map area. Slope undercutting for roads and buildings and addition of water for lawns, septic systems, and golf courses are likely to enhance landslide development. Several landslides occurred along Jack Creek Road during spring 2008, presumably because of above average (although not record-setting) spring precipitation. In places landslide deposits spread across the road. In other places part of the road was significantly down-dropped along landslide scarps (Figure 2). The Jack Creek Road landslides were probably representative of new landslide development along other roads in the area following the relatively high 2008 spring precipitation.

The slopes of steeply dipping Cretaceous sedimentary rocks on the flanks of Lone Mountain and south of the Spanish Peaks Fault in the map area are especially susceptible to mass gravitational movement. In addition, Jumbo Mountain in the Spanish Peaks Wilderness just north of the map area, has been identified as having the potential to produce a catastrophic, large-volume rockslide that could potentially impede Hell Roaring Creek and the Gallatin River. Breaching of a landslide-generated dam could be disastrous to downstream residents (Lageson and others, 1997).



Figure 2. Landslide along Jack Creek Road in northwest part of map area (July 2008 photo).

DESCRIPTION OF MAP UNITS

- Qal** **Alluvium of modern channels and flood plains (Holocene)**—Unconsolidated silt- to boulder-size, subangular to rounded clasts, moderately sorted to well sorted in flood plains; includes fine-grained overbank deposits. Larger clasts are moderately rounded to well rounded. Maximum thickness greater than 15 ft (6 m).
- Qpa** **Paludal deposits (Holocene)**—Sand, silt, and organic matter deposited in swamp environment or standing body of water, natural or man-made.
- Qta** **Talus deposit (Holocene and upper Pleistocene?)**—Angular and subangular cobble- to boulder-size clasts at base of steep valley walls or cliffs. Boulders generally as large as 2 m, although in places as large as 10 m. Locally includes minor alluvial deposits and rock-glacier deposits. Maximum thickness greater than 65 ft (20 m).
- Qrg** **Rock glacier deposits (Holocene and upper Pleistocene?)**—Hummocky, lobate deposits of angular boulders that have a frontal slope near the angle of repose; locally active. In places, grade into and include some talus deposits. About 65 ft (20 m) thick.
- Qc** **Colluvium (Holocene and upper Pleistocene)**—Unconsolidated to slightly indurated, mostly massive, dark brown to light grayish brown deposits that mantle gently to moderately sloping surfaces; sediment types are intermixed by down-slope movement. Colluvium contains cobbles and pebbles derived from weathering of bedrock. Locally includes loess that is very fine grained sand, silt, and minor clay. Commonly contains poorly to moderately developed soil profile in upper part. Includes alluvium in small channels and sheetwash on steeper hillsides. Unmapped in many areas, particularly where deposit is thin and forms discontinuous veneer. On flanks of Lone Mountain colluvium dominantly consists of angular blocky or platy clasts of dacite porphyry primarily cobble size, but as large as boulder size. Maximum thickness probably less than 30 ft (10 m).
- Qaf** **Alluvial fan deposits (Holocene and upper Pleistocene)**—Deposits east of Big Sky Meadow Village along Michener Creek and the West Fork of the Gallatin River. Deposits have fan morphology and consist of stratified alluvial deposits and poorly sorted debris-flow deposits.
- Qls** **Landslide deposit (Holocene and Pleistocene)**—Mass-wasting deposits that include slides of nearly intact rotated concave slump blocks to greatly deformed masses, earthflows, debris slides, and debris avalanches. Not necessarily represented comprehensively, and areas of relatively accelerated creep may not be included. Thickness from about 30 ft (10 m) to greater than 165 ft (50 m) thick.

- Qgt** **Glacial till (Pleistocene)**—Unsorted, unstratified, unconsolidated, subangular to subrounded boulders in an unsorted matrix with clasts as fine as silt. Most till deposited during Pinedale (about 20-14 thousand years ago) and Bull Lake (about 140-100 ka) glaciations. Pinedale-age till preserved in hummocky deposits that contain numerous closed depressions and have a thin or non-existent soil profile; deposits of Bull Lake-age till have more rounded topography, are more dissected, and generally exhibit a well-developed soil profile. As much as about 165 ft (50 m) thick.
- Qgr** **Gravel (Pleistocene)**—Cobble-pebble gravel with matrix of sand, silt, and clay. Dominant clast composition is dacite porphyry with subordinate clasts of lower Thermopolis Formation quartz arenite and other Cretaceous sandstone. Matrix includes lenses of clay. South of West Fork of Gallatin River interpreted as glacial outwash deposit with fan form morphology that is notably devoid of Archean metamorphic clasts except along the south margin of the river (Walsh, 1971). Glacial outwash also interpreted to underlie the Big Sky Mountain Village area (Montagne, 1971). Elsewhere gravel is alluvial terrace deposits. Thickness about 15 ft (4½ m).
- Qs** **Sediment (Pleistocene?)**—Underlies Big Sky Mountain Village area. Prior to development mapped as glacial outwash (Walsh, 1971). No longer exposed.
- Qd** **Younger diamicton deposit (Pleistocene)**—Unsorted, unstratified, unconsolidated matrix-supported deposit composed of angular to subangular clasts of Archean metamorphic rocks as much as 6½ ft (2 m) wide, and lesser amounts of sedimentary rocks at the base of the deposit, with minor amounts admixed throughout. Matrix ranges from loose sandy loam to firm clayey loam. Deposits have a topographically lower surface than QTd and appear incised into QTd. Fabric analysis (Larry Smith, personal communication) showed moderate fabric development.
- QTdu** **Diamicton deposit, undivided (Pleistocene and/or Pliocene)**—Unsorted, unstratified, unconsolidated matrix-supported deposit composed of subangular to subrounded clasts, as large as 6½ ft (2 m) wide, of Archean metamorphic rocks with lesser amounts of sedimentary rocks at the base of the deposit, and minor amounts admixed throughout. Matrix ranges from loose sandy loam to firm clayey loam. Fabric analysis (L. Smith) suggests that the diamicton on the divide along the west side of Beehive Basin is till that is older than the till (Qgt) in Beehive Basin. Fabric analysis of the matrix-supported diamicton at other locations in the Lone Mountain 7.5' quadrangle showed moderate fabric development. Weathering rinds and decomposed clasts suggest that deposits could be as old as Tertiary (L. Smith, personal communication). The Archean clasts must have originated from north of the Spanish Peaks Fault. The diamicton is clast-supported near the Spanish Peaks Fault and along Moonlight and Jack Creeks. Some of the clast-supported deposits have a distinct linear mound morphology. Maximum thickness greater than 20 m.
- QTd** **Older diamicton deposit (Pleistocene and/or Pliocene)**—Unsorted, unstratified, unconsolidated matrix-supported deposit composed of subangular to subrounded clasts, as much as 2 m wide, of Archean metamorphic rocks with lesser amounts of

sedimentary rocks at the base of the deposit, and minor amounts admixed throughout. Matrix ranges from loose sandy loam to firm clayey loam. Fabric analysis (L. Smith) showed moderate fabric development that was inconclusive in separating depositional mechanisms. Weathering rinds and decomposed clasts suggest that deposits could be as old as Tertiary (L. Smith, personal communication). Deposits have a topographically higher surface than Qd.

References Cited

- Carrara, P.E., and O'Neill, J.M., 2003, Tree-ring dated landslide movements and their relationship to seismic events in southwestern Montana, USA: *Quaternary Research*, v. 10, no. 5, p. 259-260.
- Doser, D.I., 1985, Source parameters and faulting processes of the 1959 Hebgen Lake, Montana, earthquake sequence: *Journal of Geophysical Research*, v. 90, p. 4537-4555.
- Garihan, J.M., Schmidt, C.J., Young, S.W., and Williams, M.A., 1983, Geology and recurrent movement history of the Bismark-Spanish Peaks-Gardiner Fault system, southwest Montana, *in* Lowell, J.D., ed., *Rocky Mountain Foreland Basins and Uplifts*, p. 295-314.
- Hadley, J. B., 1964, Landslides and related phenomena accompanying the Hebgen Lake earthquake of August 17, 1959: U.S. Geological Survey Professional Paper 435, p. 107-138.
- Kellogg, K.S., and Harlan, S.S., 2007, New $^{40}\text{Ar}/^{39}\text{Ar}$ age determinations and paleomagnetic results bearing on the tectonic and magmatic history of the northern Madison Range and Madison Valley region, southwestern Montana, U.S.A.: *Rocky Mountain Geology*, v. 42, no. 2, p. 157-174.
- Kellogg, K.S., Schmidt, C.J., and Young, S.W., 1995, Basement and cover-rock deformation during Laramide contraction in the northern Madison Range (Montana) and its influence on Cenozoic basin formation: *American Association of Petroleum Geologists Bulletin*, v. 79, p. 1117-1137.
- Kellogg, K.S., and Williams, V.S., 2000, Geologic map of the Ennis 30' x 60' quadrangle Madison and Gallatin Counties, Montana, and Park County, Wyoming: U.S. Geological Survey Geologic Investigation Series I-2690, 1:100,000 scale.
- Kellogg, K.S., and Williams, V.S., 2000, Geologic map of the Ennis 30' x 60' quadrangle Madison and Gallatin Counties, Montana, and Park County, Wyoming: Montana Bureau of Mines and Geology Open-File Report 529, 1 sheet, scale 1:100,000.
- Kellogg, K.S. and Vuke, S.M., in review, Geologic map of the Fan Mountain, Lone Mountain, and Gallatin Peak 7.5' quadrangles, Madison Range, Montana: Montana Bureau of Mines and Geology Open-File Report, scale 1:24,000.

- Lageson, D.R., Kellogg, K.S., and O'Neill, J.M., 1997, Potential for catastrophic landslide failure of northwest flank of Jumbo Mountain, Spanish Peaks Wilderness, Montana, *in* Lageson, D.R., ed., *The edge of the Crazy's: geology where the mountains meet the prairie: Northwest Geology*, v. 27, p. 13-18.
- McMannis W.J., and Chadwick R.A., 1964, Geology of the Garnet Mountain quadrangle, Gallatin County, Montana: Montana Bureau of Mines and Geology Bulletin 43, 47 p.
- McMillion, Scott, 2000, Bones found on peak may be those of long-lost climber: *Bozeman Daily Chronicle*, 8/21/2000:
<http://www.bozemandailychronicle.com/articles/2000/08/21/news13496.txt> [accessed 8/12/09].
- Montagne, C.M., 1971, Quaternary and environmental geology of part of the West Fork Basin, Gallatin County, Montana: Bozeman, Montana State University M.S. thesis, 89 p.
- Pardee, J.T., 1950, Cenozoic block faulting in western Montana: Geological Society of America Bulletin, v. 62, p. 359-406.
- Qamar, A., and Hawley, B., 1979, Seismic activity near the Three Forks Basin, Montana: Bulletin of the Seismological Society of America, v. 69, no. 6, p. 1917-1929.
- Ruleman, C.A., and Lageson, D.R., 2002, Late Quaternary tectonic activity along the Madison fault zone, southwest Montana: Geological Society of America Abstracts with Program, v. 43, no., 4, p. 12.
- Smith, Larry, personal communication, 2008, Hydrogeologist, Montana Bureau of Mines and Geology hydrogeologist.
- Smith, R.B., and Arabasz, W.J., 1991, Seismicity of the Intermountain Seismic Belt, 1991, *in* Slemmons, D.B., Engdahl, E.R., Zoback, M.R., Zoback, M.L., and Blackwell, D.D.L, eds, Neotectonics of North America, Decade of North American Geology: Geological Society of North America, SMV V-1, p. 185-228.
- Smith, R.B., and Sbar, M.L., 1974, Contemporary tectonics and seismicity of the western United States with emphasis on the Intermountain Seismic Belt: Geological Society of America Bulletin, v. 85, no. 8, p. 1205-1218.
- Stickney, M.C., personal communication, 2009, Director, Montana Bureau of Mines and Geology Earthquake Studies Office.
- Stickney, M.C., 1995, Montana seismicity report for 1990: Montana Bureau of Mines and Geology Miscellaneous Contribution 16, 44 p., 1 sheet.
- Stickney, M.C., 1988, Montana seismicity report for 1986: Montana Bureau of Mines and Geology Open-File Report 204, 39 p.

- Stickney, M.C., Haller, K.M., and Machette, M.N., 2000, Quaternary faults and seismicity in western Montana: Montana Bureau of Mines and Geology Special Publication 114, scale 1:750,000.
- Stickney, M.C., 2007, Historic earthquakes and seismicity in southwestern Montana: *in* Thomas, R.C. and Gibson, R.I., eds., Tobacco Root Geological Society Field Conference, Dillon, Montana: Introduction to the Geology of the Dillon Area: Northwest Geology v. 36, p. 167-186.
- Tysdal, R.G., Marvin, R.F., DeWitt, E.H., 1986, Late Cretaceous stratigraphy, deformation, and intrusion in the Madison Range of southwestern Montana: Geological Society of America Bulletin, v. 97, p. 859-868.
- Walsh, T.H., 1971, Quaternary geology of the east portion of West Fork Basin, Gallatin County, Montana: Bozeman, Montana State University, M.S. thesis, 83 p.
- Witkind, I.J., 1960, The Hebgen Lake, Montana, earthquake of August 17, 1959, *in* Campau, D.E., Anisgard, H.W., and Egbert, R.L., eds., West Yellowstone–Earthquake area, Billings Geological Society 11th Annual Field Conference Guidebook, p. 31-44.
- Wong, Ivan, Olig, Susan, Dober, Mark, Wright, Douglas, Nemser, Eliza, Lageson, David, Silva, Walter, Stickney, Michael, Lemieux, Michele, and Anderson, Larry, 2005, Probabilistic earthquake hazard maps for the State of Montana: Montana Bureau of Mines and Geology Special Publication 117, 72 p.

Montana Bureau of Mines and Geology
Open File 581

**Geologic Map of Landslide and Other Cenozoic Deposits
Big Sky-Moonlight Basin-Lost Lake Area
Madison Range, Montana**

Susan M. Vuke

2009

Legend

- Lines dashed where inferred; dotted where concealed
- Contact
- Thrust Fault
- Reverse Fault
- Normal Fault
- Syncline
- Anticline
- Landslide scarp (not all are shown)
- Top of selected landslide deposits

Map Units

- Qal Alluvium of modern channels and flood plains
- Qpa Paludal deposit
- Qta Talus deposit
- Qrg Rock glacier deposit
- Qc Colluvium
- Qaf Alluvial fan deposit
- Qls Landslide deposit - not necessarily represented comprehensively, and areas of relatively accelerated creep may not be included.
- Qgl Glacial till
- Qgr Gravel
- Qs Sediment, undivided
- Qd Diamiction, younger than QTd
- QTdu Diamiction, undivided
- QTd Older diamiction deposit
- Pre-Cenozoic rocks
- Deposits with abundant spherical to oblong, subangular to subrounded boulders and cobbles composed of Archean metamorphic rocks, relatively few Cretaceous sedimentary rocks, and rare dacite porphyry clasts.
- Deposits with platy angular and lesser spherical, rounded clasts composed of dacite porphyry and subordinately of Cretaceous sedimentary rocks. Deposits devoid of Archean metamorphic clasts.
- Deposits with clasts that include both Archean metamorphic rocks and dacite porphyry.

Primarily Archean metamorphic rocks not shown on map

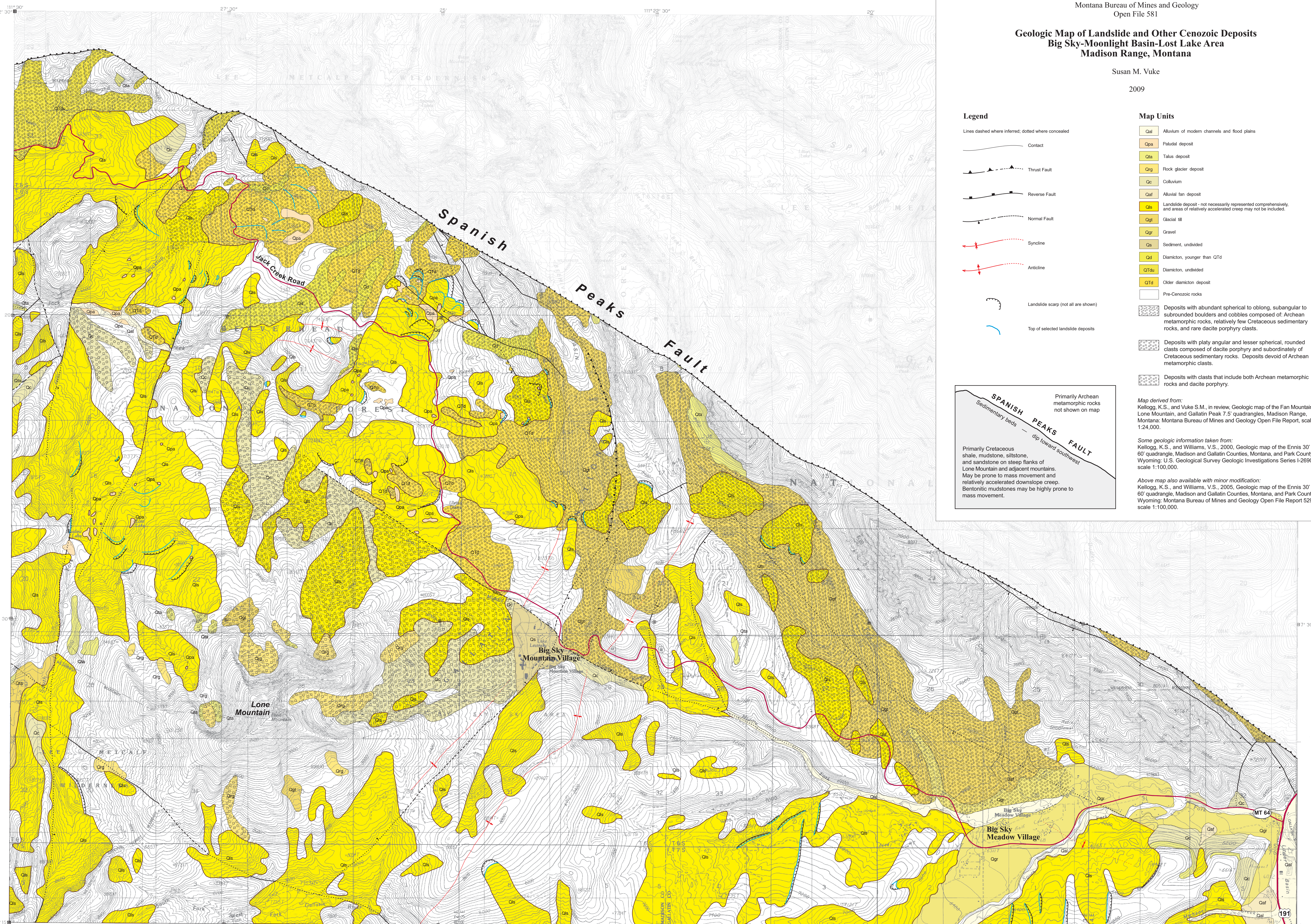
SPANISH PEAKS FAULT
Sedimentary beds — dip toward southwest

Primarily Cretaceous shale, mudstone, siltstone, and sandstone on steep flanks of Lone Mountain and adjacent mountains. May be prone to mass movement and relatively accelerated downslope creep. Bentonitic mudstones may be highly prone to mass movement.

Map derived from:
Kellogg, K.S., and Vuke S.M., in review, Geologic map of the Fan Mountain, Lone Mountain, and Gallatin Peak 7.5' quadrangles, Madison Range, Montana; Montana Bureau of Mines and Geology Open File Report, scale 1:24,000.

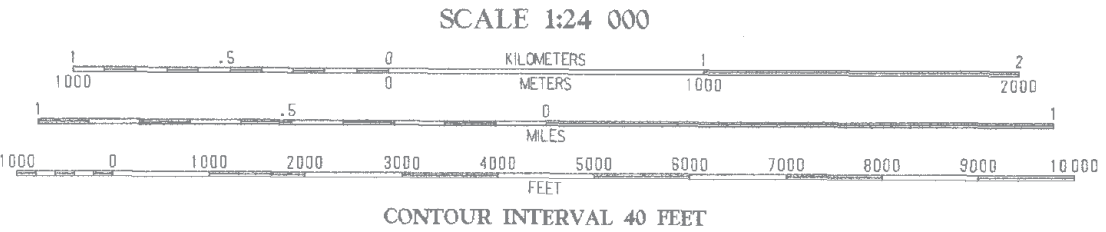
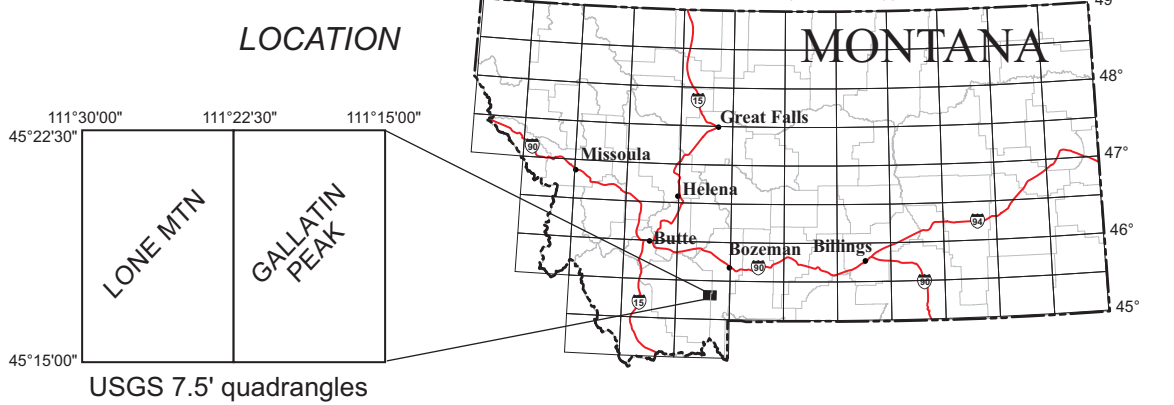
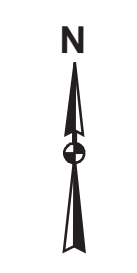
Some geologic information taken from:
Kellogg, K.S., and Williams, V.S., 2000, Geologic map of the Ennis 30' x 60' quadrangle, Madison and Gallatin Counties, Montana, and Park County, Wyoming; U.S. Geological Survey Geologic Investigations Series I-2690, scale 1:100,000.

Above map also available with minor modification:
Kellogg, K.S., and Williams, V.S., 2005, Geologic map of the Ennis 30' x 60' quadrangle, Madison and Gallatin Counties, Montana, and Park County Wyoming; Montana Bureau of Mines and Geology Open File Report 529, scale 1:100,000.

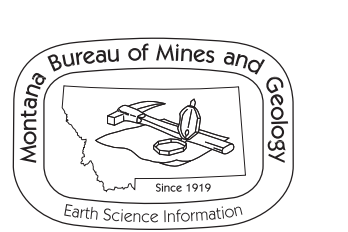


Base maps from U.S. Geological Survey
Lone Mountain 7.5' topographic quadrangle
Map date: 1988
Projection: Lambert Conformal Conic
UTM zone 12, 1927 NAD
UTM Grid Declination: 0°19' West
1988 Magnetic North Declination: 15°30' East

Gallatin Peak 7.5' topographic quadrangle
Map date: 1988
Projection: Lambert Conformal Conic
UTM zone 12, 1927 NAD
UTM Grid Declination: 0°13' West
1988 Magnetic North Declination: 15°30' East



CONTOUR INTERVAL 40 FEET



Maps may be obtained from: Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-8997
Phone: (406) 496-4167
Fax: (406) 496-4451
<http://www.mbmng.mtech.edu>