Geology for land use planning, Jack Creek Basin, Madison County, Montana
by Robert Falkner Grabb

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Earth Sciences
Montana State University

Abstract:
The Jack Creek basin is located in the Madison Range of southwestern Montana, adjacent to a major, year-round recreational complex. The basin forms a natural avenue through the range along which a 161 kilovolt electrical transmission line and a road have been tentatively routed. Almost the entire basin is primitive and roadless and has been included in an addition to the proposed Spanish Peaks wilderness area, which lies on the northern margin of the basin.

The Jack Creek basin is a downdropped block bounded on the south by two intrusive complexes. The intrusions consist of highly jointed andesite-dacite sills. Two of these sills are exposed by Jack Creek. The sills intruded Upper Cretaceous rocks. The Upper Cretaceous rocks crop out in the majority of the basin. Glacial deposits veneer much of the basin.

Geologic hazards are common in the Jack Creek basin. The most frequently encountered hazards are rockfalls, slump-earthflows, snow avalanches, and seismic intensity hazards. The Intermountain seismic belt (ISB) is an area of high seismicity located immediately west of the basin. In addition to the seismic intensity hazards associated with the ISB, the earthquakes which occur along this belt may act as catalysts for other geologic failure.

The jointed igneous intrusions are very susceptible to rockfall. This is indicated by the extensive talus slopes which have accumulated in the areas where these rocks are exposed. The most widespread geologic hazard, slump-earthflows, have developed on Upper Cretaceous rocks. These rocks are characterized by expansive clays, impermeability, and low shear strength. Most of the precipitation received by the Jack Creek basin occurs in the form of snow. The combination of high snowfall and large areas in slope results in snow avalanches.

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December, 1977

ACKNOWLEDGEMENT

The author is indebted to Dr. John Montagne, who first suggested the problem and critically read the manuscript. Thanks are also extended to Dr. Donald Smith for his assistance in the field and critical review of the manuscript. Dr. Robert Chadwick also reviewed the manuscript.

Partial funding was supplied by Sigma Xi.

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ABSTRACT

The Jack Creek basin is located in the Madison Range of southwestern Montana, adjacent to a major, year-round recreational complex. The basin forms a natural avenue through the range along which a 161 kilovolt electrical transmission line and a road have been tentatively routed. Almost the entire basin is primitive and roadless and has been included in an addition to the proposed Spanish Peaks wilderness area, which lies on the northern margin of the basin.

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Geologic hazards are common in the Jack Creek basin. The most frequently encountered hazards are rockfalls, slump-earthflows, snow avalanches, and seismic intensity hazards. The Intermountain seismic belt (ISB) is an area of high seismicity located immediately west of the basin. In addition to the seismic intensity hazards associated with the ISB, the earthquakes which occur along this belt may act as catalysts for other geologic failure.

The jointed igneous intrusions are very susceptible to rockfall. This is indicated by the extensive talus slopes which have accumulated in the areas where these rocks are exposed. The most widespread geologic hazard, slump-earthflows, have developed on Upper Cretaceous rocks. These rocks are characterized by expansive clays, impermeability, and low shear strength. Most of the precipitation received by the Jack Creek basin occurs in the form of snow. The combination of high snowfall and large areas in slope results in snow avalanches.

Chapter 1

INTRODUCTION

Statement of Problem

The geology of the Jack Creek basin is complex; within the boundaries of the basin, active and potential geological hazards exist. The numerous slopes mantled by landslide deposits and rockfall debris attest to the general geologic instability. The basin is located immediately west of one of the most seismically active areas in the Rocky Mountains, and active faults are known throughout the region. To ensure the wisest and most resourceful use of the area, existing geologic constraints must be identified.

The mountainous regions of Montana have been traditionally the last areas of the state to be developed. Historically, most of man's activities were confined to the lower elevations and less rugged terrain. However, increased recreational time and improved access has led to the development of Montana's mountainous areas.

The Jack Creek basin adjoins a major recreational complex, Big Sky of Montana, Inc. The basin forms a natural corridor which connects the Madison Valley and the upper Gallatin Valley. The corridor is a natural avenue along which several engineering projects have been tentatively routed. These include a 161,000 volt electrical transmission line and a road connecting Ennis and Big Sky (Figure 1).

Much of the western portion of the basin has been included in

an addition to the proposed Spanish Peaks Wilderness Area. Obviously these proposals suggest that the area possesses true wilderness character.

Purpose

Numerous formations are exposed in the deformed strata of Montana's mountains, and each formation has a different potential for development. This report is an attempt to identify the inherent geological limitations of the Jack Creek basin. The general geological relationships, structure, stratigraphy, and geomorphology, are discussed primarily as they relate to the geologic limitations of the area.

Location

The Jack Creek basin is located in the Madison Range of southwestern Montana (Figure 1), approximately 8 miles (13 km) east of Ennis. To the north, the basin is bounded by the Spanish Peaks, an uplifted block of Precambrian metamorphic rocks. The western boundary coincides with the north-trending Madison Range piedmont fault zone. Lone Mountain and Fan Mountain delineate the eastern and southern borders of the basin respectively (Figure 1).

This report is primarily concerned with the geology along the course of upper Jack Creek. A corridor, approximately eight miles (12.8 km) long and two miles (3.2 km) wide, centered on the creek

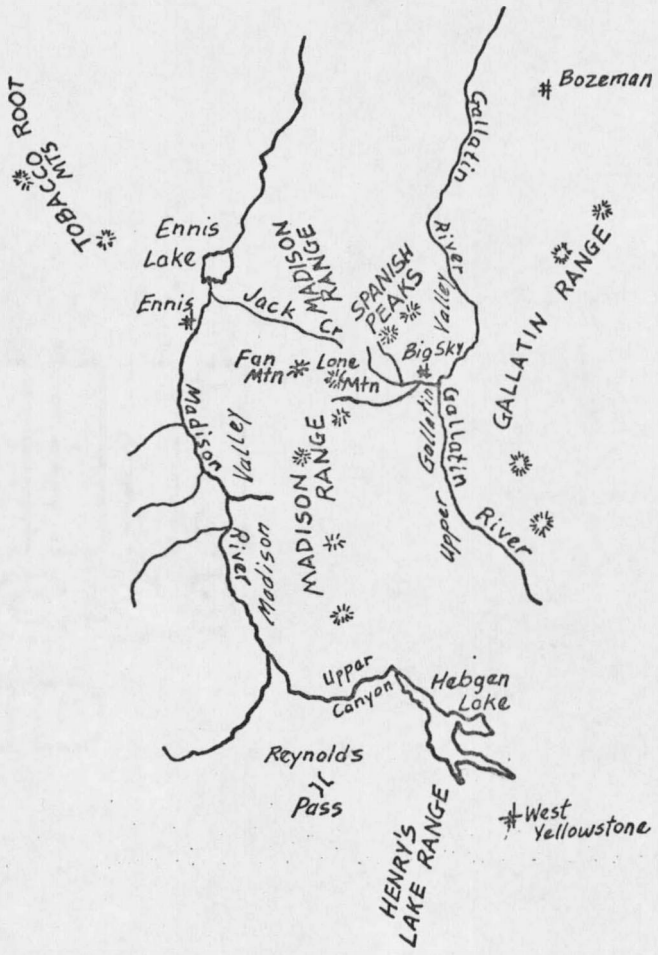

Figure 1. Index Map

would be the most likely site for future development.

Access

The Jack Creek Campground, a U. S. Forest Service primitive

campground, is located approximately 10 miles (16 km) east of Ennis on the western edge of the basin. Improved gravel roads are maintained to the Jack Creek campground from Ennis. The Big Sky road, which terminates at Ulery's Lake, connects U. S. Highway 191 with the eastern border of the basin.

Within the confines of the basin, roads are practically nonexistent; however, numerous trails provide access to the more remote points. This network of trails is well-maintained by the U. S. Forest Service. The proposed addition to the Spanish Peaks wilderness and U. S. Forest Service land is shown on Figure 2.

Geographic Setting

Jack Creek, a tributary of the Madison River, drains the rugged, mountainous area. Elevations in the basin range from 4,900 feet (1,737 km) to an impressive 11,100 feet (3,403 km) at summit of Lone Mountain. The basin is characterized by steep, densely forested slopes and broad meadows drained by clear, cold, high-gradient streams.

The Madison Range is included in the southwestern Montana mountain group of the Northern Rocky Mountain physiographic province (Thornbury, 1965). The topography of southwestern Montana is dominated by numerous linear ranges and intermontane basins. The basins are locally called valleys despite the fact that they are structurally controlled. According to Thornbury (1965), "If it were not for the intervening Snake River lava plain, these mountains could logically

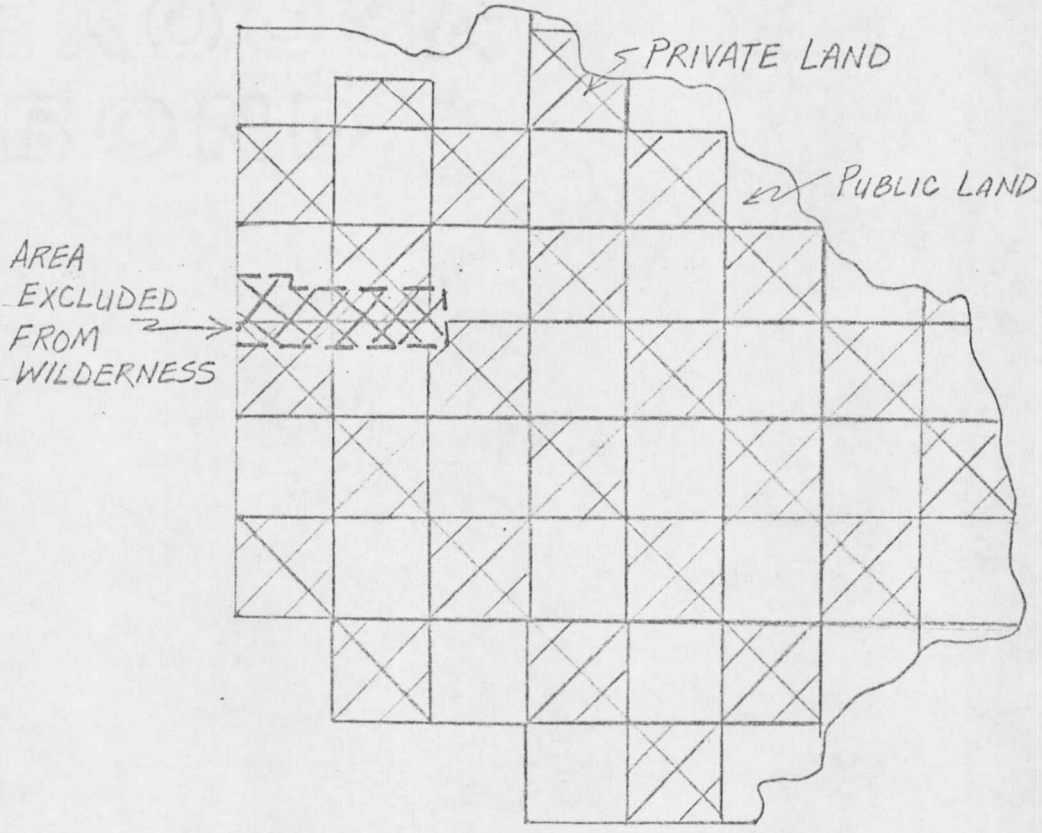

Figure 2. Addition to the Proposed Spanish Peaks Wilderness and U. S. Forest Service Lands.

be included in the Basin and Range province."

Climate

The climate of the Jack Creek basin is more similar to that of West Yellowstone (Figure 1) than that of Ennis. Records from the U. S. Weather Bureau station at West Yellowstone, Montana, reveal the following data:

Mean annual precipitation	21.11 in.	(53.62 cm)
Mean annual snowfall	155.2 in.	(394.2 cm)
Mean annual temperature	51.5° F	(12.8° C)
Mean maximum temperature	55.0° F	(10.8° C)
Mean minimum temperature	18.5° F	(-7.5° C)
Lowest temperature recorded	-66.0° F	(-54.4° C)

Hall (1961) compared the data reported from the West Yellowstone weather station with the other Montana stations and concluded,

"1. Only five stations report a lower mean annual temperature, and none of these is as much as 1° lower.
2. No station reports as low a mean minimum temperature.
3. No other station has recorded as low an indiviudal temperature (-66°).
4. Only four stations report a greater mean annual snowfall.
5. No region in the state appears to have a shorter growing season."

Hall believed these observations are significant, and an appreciation of their implications will lead to a better understanding of the geomorphic history of the area. The climate definitely affects the geologic limitations of the basin. Frost-wedging is a very effective

weathering agent in this climate and is responsible of the maintenance of the rockfalls in the basin. Snow avalanches must be considered in a climate which has a mean annual snowfall of 155.2 in. (394.2 cm).

Drainage

Tributaries that unite to form Jack Creek include; Hammond Creek, Mill Creek, Aspen Creek, Levi Creek, Wickiup Creek, Moonlight Creek, the South Fork of Jack Creek, Long Creek and several smaller unnamed streams. Jack Creek flows into the Madison River upstream of Ennis Lake. Sediment is filling this lake, and heating of the water occurs during the summer. This has had an adverse affect upon the fisheries of the Madison River.

Methods of Study

Approximately twenty-eight square miles (72 km^2) of the Jack Creek basin were mapped by the author during ten weeks of the summer of 1976 (Figure 3). These field observations are shown on Plate I, The Geology of the Jack Creek Basin. The base map for this study was photographically prepared from two U. S. Geological Survey fifteen-minute topographic maps, the Ennis quadrangle and the Spanish Peaks quadrangle. These were enlarged to a scale of 1:24,000. This scale was chosen so that this report could be augmented by Soil Conservation Service soil surveys.

The area mapped straddles the course of upper Jack Creek, the