Quaternary and environmental geology of part of the West Fork Basin, Gallatin County, Montana
by Clifford Montagne

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Earth Science (Geology)
Montana State University

Abstract:
The West Fork (of the Gallatin River) lies in the Madison Range between Bozeman and West Yellowstone, Montana, It is the site of Big Sky of Montana, a proposed year round recreation and real estate development, Field work was partially funded by the National Science Foundation for a project entitled Impact of a Large Recreation Area on a Semiprimitive Environment.

The West Fork basin is a structural and topographic basin in the Northern Rocky Mountain Physiographic Province. It is bounded on the north by the crystalline Spanish Peaks and on the west by the Lone Mountain intrusive complex. The basin exposes Cretaceous bedrock.

Quaternary geology was mapped jointly by A. Kehew, H. Walsh and the writer, pre-Wisconsin glacial till is associated with a 2 million year old welded tuff. Till position and regional correlation indicate the existence of a pre-Wisconsin ice cap over the Spanish Peaks, filling the West Fork basin with ice. Bull Lake (early Wisconsin) glaciers filled the North Fork and Beehive valleys with ice and terminated on or near the main basin floor. Pinedale glaciers were smaller than the Bull Lake glaciers, Hillslopes of Cretaceous bedrock, mantled with Bull Lake till, slid during the Pinedale deglaciation.

Neoglacial moraines and talus flows are found in the highest cirques.

Wisconsin glaciers, originating in the east facing cirques on Lone Mountain, reached the vicinity of the upper village site (S30, T6S, R3E). An inactive Neoglacial rock glacier now occupies the cirque. It is partially covered by an active rock glacier.

Landsliding is still active, especially where hillslope equilibrium is disturbed by construction. Excess water, alternating folded sandstones and shales, clays, steep, slopes, and till overload have caused past and present sliding.

Potential rockfalls and snow avalanches pose threats to mountain use.

The proposed upper village site lies on outwash and till which covers shale bedrock. North of this site are some active slide tension cracks. Soils mapping is correlated with the surficial geology. Many soil boundaries correspond to surficial geology boundaries. Clay soils developed on shale are poor building sites.

Some areas with unique natural habitats should be left as natural preserves.

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Signature Clifford Montagne

Date 18 June 1971

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August, 1971

Acknowledgements

The writer thanks his parents, who introduced him to geology and supported the present study in every way. His father, John Montagne, was the Geologic Investigator for the National Science Foundation project and provided help in the field and office. Through Professor C. C. Bradley's initiative, the National Science Foundation study became a reality. In addition to being a neighbor and friend, he served as the writer's Major Professor. Prof. Bradley, Dr. V. Mitchell and Dr. D. Dunn gave invaluable help in the preparation of this thesis. Dr. J. H. Rumley and Dr. G. A. Nielsen provided assistance in botany and soils. The writer thanks Jim and Patty Goodrich of the 320 Ranch, who introduced him to the country and its way of life. Sam Smeding allowed the hunting camp to be used as a base for field work. From keeping camp to proofreading, Joan Montagne contributed to the project in all ways possible.

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ABSTRACT

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INTRODUCTION

Figure 1. East side of Lone Mountain, showing the large cirque and rock glaciers.

LOCATION

This report concerns the Environmental and Quaternary geology of a portion of the drainage of the West Fork of the Gallatin River, midway between Bozeman and West Yellowstone, Montana. The West Fork basin is the proposed site of Big Sky of Montana, a recreation and living development. The particular area under study is bounded on the south by the Middle Fork of the West Fork, on the north by the Spanish Peaks, and on the west by a northward bearing from Lone Mountain to the Spanish Peaks.

PHYSIOGRAPHIC SETTING

The area lies at the southern end of the Northern Rocky Mountain Physiographic Province, a subdivision of the Rocky Mountain System (Thornbury, 1964). Local relief encompasses elevations from the Gallatin Canyon at 6,000 feet; to the summits of the Spanish Peaks and Lone Mountain at over 11,000 feet. It is an area of high relief, with peaks, cirques and moderately incised canyons which discharge to the alluvial level of the Gallatin River. The topography is controlled by bedrock structural features and modified by glaciation and other mass movement. Some striking examples of stream superposition exist. The terrain is in the youthful to early-mature stage of geomorphic development.

GEOLOGIC SETTING

The material for this section has been taken from Swanson (1950), Hall (1961), and McMannis and Chadwick (1964). Figure 2a is a sketch map showing the local setting and some structural features. Figure 2b is a topographic map of the study area.

The Madison-Gallatin uplift is a broad anticlinal uplift and faulted block with exposures of Pre-Cambrian to Tertiary rock. The Gallatin River flows north along a structural low in the middle of the uplift, separating the Madison Range on the west from the Gallatin Range on the east. The West Fork basin (structural and topographic) lies in the Madison Range and is bordered by the Gallatin River on the east, the Spanish Peaks on the north, the Gallatin-Madison Divide on the west, and the Buck Creek anticline on the south.

The Spanish Peaks Fault is a high angle reverse fault which runs in a northwest direction along the north side of the West Fork basin. The crystalline Spainsh Peaks rise on the north side of the fault, which has at least 10,000 feet of displacement. It elevated the Spanish Peaks in Cretaceous to Eocene time. The Spanish Peaks Fault is overlapped by Tertiary volcanics east of the Gallatin River. The fault system may extend as far as Gardiner, Montana.

South of the Spanish Peaks, folded sedimentary rocks are exposed. The Lower Basin syncline parallels the Spanish Peaks Fault and forms most of the West Fork basin. The Buck Creek anticline, also trending

parallel to the Spanish Peaks Fault, extends to the Snowflake fault zone near the boundary of Yellowstone National Park. Most of the exposed sedimentary rocks in the West Fork basin are sandstones and shales of Cretaceous age. A stratigraphic description is found in the Appendix.

Andesite anticline is cut at both ends by faults. It may be related to the Lone Mountain intrusive complex.

Lone Mountain is a multiple horizon laccolithic intrusion, in which Andesite porphyry alternates with sedimentary layers. Fan, Cedar, and Pioneer Mountains to the southwest are similar to Lone Mountain. Andesitic sills are found in the western portion of West Fork basin and are porbably related to Lone Mountain.

East of the West Fork basin, the Gallatin Range has been covered by a pile of volcanic pyroclastics and sediments, which extends south beyond the Yellowstone Park boundary. The southern Gallatin Range consists of folded sedimentary rocks and intrusives. The southern Madison Range consists of folded sedimentary rocks and exposed basement rock.

Thus the West Fork basin is a structural low of folded and faulted sedimentary rocks, with the crystalline Spanish Peaks on the north and the multiple intrusive, Lone Mountain, on the west. The basin is filled with relatively non-resistant rocks, whereas the Spanish Peaks complex is an uplifted block of relatively resistant rock, hence the

topographic difference.

PREVIOUS GEOLOGICAL WORK

Early geologic exploration in the region was done in the late 1800's by F. V. Hayden, A. C. Peale, J. P. Iddings and W. H. Weed. A. C. Peale (1893) also mapped the Three Forks (Montana) Quadrangle, an area about the size of Yellowstone Park which includes the West Fork area. Peale's work in the West Fork remained the only work until R. W. Swanson (1950) mapped a part of the Three Forks Quadrangle, including the area of this study. His map was used as the basis for the bedrock geology of this study. J. A. Wilsey Jr. (1948) mapped in the upper Gallatin area in the late 1940's, but didn't finish the work before his death. W. B. Hall, now of the University of Idaho, carried on Wilsey's work with his own Ph. D. thesis (Hall, 1961) and other publications. Wilsey's and Hall's work is concentrated in an area to the south of West Fork. However, thier work, and W. B. Hall's personal consultations have been a great aid to the writer.

W. J. McMannis and R. A. Chadwick, of Montana State University, mapped the geology of the Garnet Mountain Quadrangle, which is directly east of the Spanish Peaks Quadrangle and West Fork (McMannis and Chadwick, 1964).