Erosional surfaces and glacial geology along the southwest flank of the Crazy Mountains, Montana
by John P Bluemle

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Applied Science with a major in Geology
Montana State University

Abstract:
Significant and interesting geomorphic-glacial relations along the southwest margin of the Crazy Mountains provide data for an understanding of a series of late Cenozoic surfaces. Paleocene (Fort Union) sandstones, into which stocks, sills and dikes have been intruded, comprise the relatively homogeneous sedimentary succession underlying the area. The gently northerly dipping beds do not greatly affect the geomorphology of the area.

Four surface systems, formed by laterally planating streams issuing from the Crazy Mountains, are of the following ages.

Surface I ----- early Pleistocene or late Pliocene Surface II ---- early to mid-Pleistocene Surface III---- early Wisconsin Surface IV ---- intra-Wisconsin Gravels, probably indicative of older surface remnants, are also present on high benches above surface I. Although the present Yellowstone River flows eastward, the presence in the Gallatin Valley of gravels from the Crazy Mountains, suggests that drainage prior to the cutting of surface I was directed westward.

In the north, erosion since the latest glacial advance has been confined to deep, narrow valleys, whereas in the south, where erosion has been more effective, valleys are wide and only small remnants of the earlier surfaces remain.

Ages of the two youngest surfaces were determined after appraisal of their relationships with glacial features. Two substages of Wisconsin glaciation are recognized; the latest moraine is fresh, the earliest quite subdued. They are easily distinguished in the field by comparison.

Contrary to Alden's (1932) belief, I have classified surface II as Pleistocene and therefore younger than the Flaxville Plain as it was defined in northern Montana.

Statistical studies indicate increasing sphericity and roundness and decreasing size with transport distance except on the oldest surface. The studies show that the three younger surfaces were stream-carved, but the oldest surface has undergone modifying influences, due either to its greater age and length of exposure or reworking by glaciers.

EROSIONAL SURFACES AND GLACIAL GEOLOGY ALONG THE SOUTHWEST FLANK OF THE CRAZY MOUNTAINS, MONTANA

by

JOHN P. BLUEMLE

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

of

Master of Science in Applied Science
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Approved:

Head, Major Department

Chairman, Examining Committee

Dean, Graduate Division

MONTANA STATE COLLEGE
Bozeman, Montana

April, 1962

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ABSTRACT

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INTRODUCTION

Location

The area undertaken for study is located in northeastern Park County, Montana, on the southwestern flank of the Crazy Mountains. Approximate limits of the area are highway 89 on the west, 46°00' North latitude on the north, and the Park County line on the east. The southern limit lies along an east-west line about four miles north of the Yellowstone River. The area includes about 200 square miles but parts of it received much more concentrated study than others.

Purposes of This Study

Primary purposes of the study were threefold. One goal was to describe the geomorphology of the area with particular reference to the broad, flat erosional surfaces which head near the mountains and extend westward to the Shields River. A second objective was to investigate the glacial deposits with particular attention to learning the relative ages of these deposits and the surfaces. Finally, an attempt was made to learn the manner in which the pediment-like surfaces were formed and, if possible, to extend these findings to a general understanding of the processes responsible for pediment formation, especially in areas of essentially homogeneous lithology.

The methods of the study, aside from simple field observation and deduction, included the statistical analyses of 42 gravel samples collected in selected localities. Study of the bedrock, insofar as it was pertinent to the project, contributed to a greater understanding of the geomorphology.

General Physiography

The overall topographic pattern is one of broad, flat erosional surfaces which are being deeply dissected by streams. Several gravel-capped remnants are all that remain of the surfaces in the southern part of the area which has been more thoroughly dissected than the northern part. The surfaces are interrupted and separated in places by large asymmetrical hills and ridges which have, with few exceptions, steep southern and gentle northern slopes. Near the mountains, relief is considerable; the terrain covered by glacial deposits is very hummocky.

The area is flanked by the towering southern Crazy Mountains which reach an elevation of 11,214 feet. In contrast, the southwestern part of the area has elevations as low as 4500 feet. Some of the larger streams, notably Cottonwood Creek and Rock Creek, flow in canyons over 400 feet deep.

In places, the subdued topography of the mapped area is broken by small dikes which stand above the general landscape; near the mountains several dikes stand as high as 40 feet above the surrounding landscape.

The higher areas are well watered; there are heavy snows in winter and frequent showers in summer, some of which are of a cloudburst nature. Character of vegetation varies with elevation, the lower reaches being covered by grass and sage, the higher by evergreen trees. Areas of moraine are extensively forested with thick evergreen growth and in some valleys aspen and cottonwood grow in abundance. Wheat is raised on the lower surfaces and alfalfa along the Shields River in irrigated areas.

Most drainages are directed southwestward toward the Shields River which in turn flows southeast into the Yellowstone River, the regional master stream. Several small perennial streams are spring-fed, but most are fed by surface runoff.

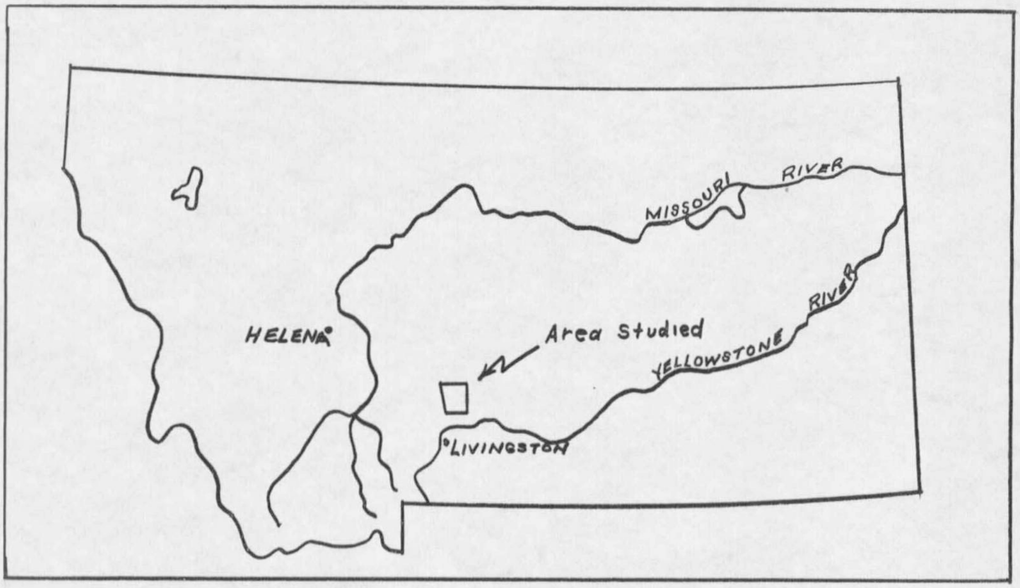

Figure 2.--Index Map of Montana

Previous Investigations

In spite of accessibility, geomorphic investigations in the Crazy Mountains area have been limited. Lewis and Clark passed the southern foot of the mountains in 1806 and named the Shields River. F. V. Hayden in 1872 speaks of the distant range (he called them the "Crazy Woman Mountains"), and Captain Ludlow's expedition in 1873 passed down the south fork of the Musselshell River, at the north end of the range, where E. S. Dana, the accompanying geologist, noted the theralite sills of Comb Creek.

The first geologic exploration was made in 1883 by J. E. Wolff working for the Northern Transcontinental Survey. Wolff (1891, 1938) published two papers of a general nature on the Crazy Mountains both primarily concerned with the igneous rocks of the area. Walter H. Weed, accompanied by J. P. Iddings and L. V. Pirsson, made trips in 1890 and 1895 for the United States Geological Survey. These workers described the areal and structural geology of the Livingston and Little Belt Mountains areas (Iddings and Weed, 1894; Weed, 1899).

G. R. Mansfield (1909) published a brief paper of a general nature on glaciation in the Crazy Mountains. Of interest too, is Alden's (1932) paper on the physiography and glacial geology of eastern Montana which treats briefly of the area.

Very little work has been done in recent years in the Crazy Mountains vicinity and although the Billings Geological Society did conduct a field conference in the Crazy Mountain Basin in 1957, very little of this was concerned with the geomorphology of the area.

Acknowledgments

Sincere appreciation is extended to Dr. John de la Montagne for his genuine interest and guidance during the preparation of this thesis. Dr. W. J. McMannis aided materially by his timely suggestions and instruction. Thanks are due also to Drs. C. C. Bradley, Nicholas Helburn, R. A. Chadwick, and Mr. M. J. Edie, of the Department of Earth Sciences at Montana State College. The Department of Earth Sciences supplied field equipment for the study.

I am indebted to Messrs. Bill and Ed Eyman for providing suitable

camping grounds and shelter during inclement weather as well as invaluable advice on local roads.

REGIONAL GEOLOGY

Introduction

The Crazy Mountains, southernmost and highest of several consanguineous isolated mountain masses extending through central Montana northward nearly to the Canadian boundary, lie between the meridians of 110°15' and 110°45' West longitude, and parallels of 45°45' and 46°30' North latitude. The general trend is a little west of north, their length about 45 miles, and their width 25 miles. They are a cluster of high and rugged peaks, whose structure, together with the unusual lime-alkalic character of the igneous rocks and the magnificent exposures, give them geologic interest. Bedrock consists of sandstones and shales of late Cretaceous to Paleocene age into which three cores of igneous rock of Eocene age have been injected accompanied by thousands of associated laccoliths, sills and dikes.

Stratigraphy

Most of the sedimentary rocks exposed in the area are of Paleocene (Fort Union) age, and comprise the upper part of the Livingston formation which is widely distributed throughout the Crazy Mountain Basin. The Livingston formation consists of andesitic sandstones and shales of late Cretaceous to Paleocene age. Some writers prefer to restrict the Livingston rocks to the latest Cretaceous and call the Paleocene part Fort Union. McMannis (1955) mapped the top of the Hell Creek member of the Livingston formation several miles west of the Shields River and considered everything to the east of this line to be of Paleocene age (see Figure 2). The Hell Creek is the uppermost Cretaceous member of the Livingston formation.

According to Wolff (1938), massive sandstones and some shales generally predominate west of the Crazy Mountains but in the mountains these give way to shales interbedded with a few thin limestones. Sandstones of the lower area near the Shields River are andesitic but they become less so toward the east. The rocks are mostly medium-grained drab, olive-gray to yellow, tuffaceous to arkosic sandstones. Clastic constituents are quite variable consisting of angular to sub-angular fragments of quartz, microcline, orthoclase, sodic to calcic plagioclase and a few grains of decomposed biotite, hornblende and augite as well as accessory minerals. Rounded fragments of limestone are commonly found interbedded and in places, carbonate fills interstices and replaces clastic grains. Wolff (1938) found a bed of conglomerate, 25 feet thick, at the extreme head of Cottonwood Creek interbedded in the sandstones. The pebbles are quartz, porphyritic igneous rocks, banded flinty slate, quartzite and a crinoidal limestone of Carboniferous age.

Structure

An asymmetric syncline involving the youngest (Fort Union) beds and trending northeast passes just south of Wilsall. The mapped area lies on the southeast, gentle flank of this syncline which causes the Fort Union beds to dip northwest at angles of from 5^{o} to 15^{o}. The northwest flank of the syncline is vertical to overturned.

Structure has not been of paramount importance in fashioning the present landscape, but it has contributed in various ways. In the central part