The geology surrounding the headwaters of Nowlin, Flat, and Granite creeks, Gros Ventre Range, Teton County, Wyoming
by Charles Matteson Love

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN APPLIED SCIENCE--PHYSICAL SCIENCE (GEOLOGY)
Montana State University

Abstract:
The geology of the southwestern Gros Ventre Range in Teton County, Wyoming, has been of a reconnaissance nature up to this time. In the 26 square mile area, Precambrian through Pennsylvanian rocks are exposed in two of the southwest-thrust blocks comprising a western portion of this range.

Geomorphic conclusions are based on reconnaissance work. A high level erosion surface exists which may have been formed during late Pliocene. Evidence of two major glaciations was found, with further indications of residual ice. Peculiarly advancing talus tongues are abundant 6 A 2,530 foot section of Cambrian through Lower Mississippian rocks was measured and found to be within the range of regional averages. A previously undescribed Tertiary (?) conglomerate is present. The mid-Cambrian Gros Ventre Formation (Wolsey-Meagher-Park equivalent) is most noted for its complex intraformational incompetencies and susceptibility to deformation under a minimal amount of stress.

The area covers part of the late Laramide Cache block anticline and its connections with the Skyline Trail block. The junction of these discloses two slightly different directions of upthrust, and although their respective erosional fronts are concordant, the southeasterly Skyline Trail block has a greater displacement. Relaxing of upthrust pressures caused an immense down-dropping of the apex of the Cache block, accounting for a major normal fault parallel to the thrust line. Most of the normal faults perpendicular to the range axis exhibit the down-thrown side to the southeast.

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Date 7/16/67

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by 441

Charles Matteson Love

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of

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ABSTRACT

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INTRODUCTION

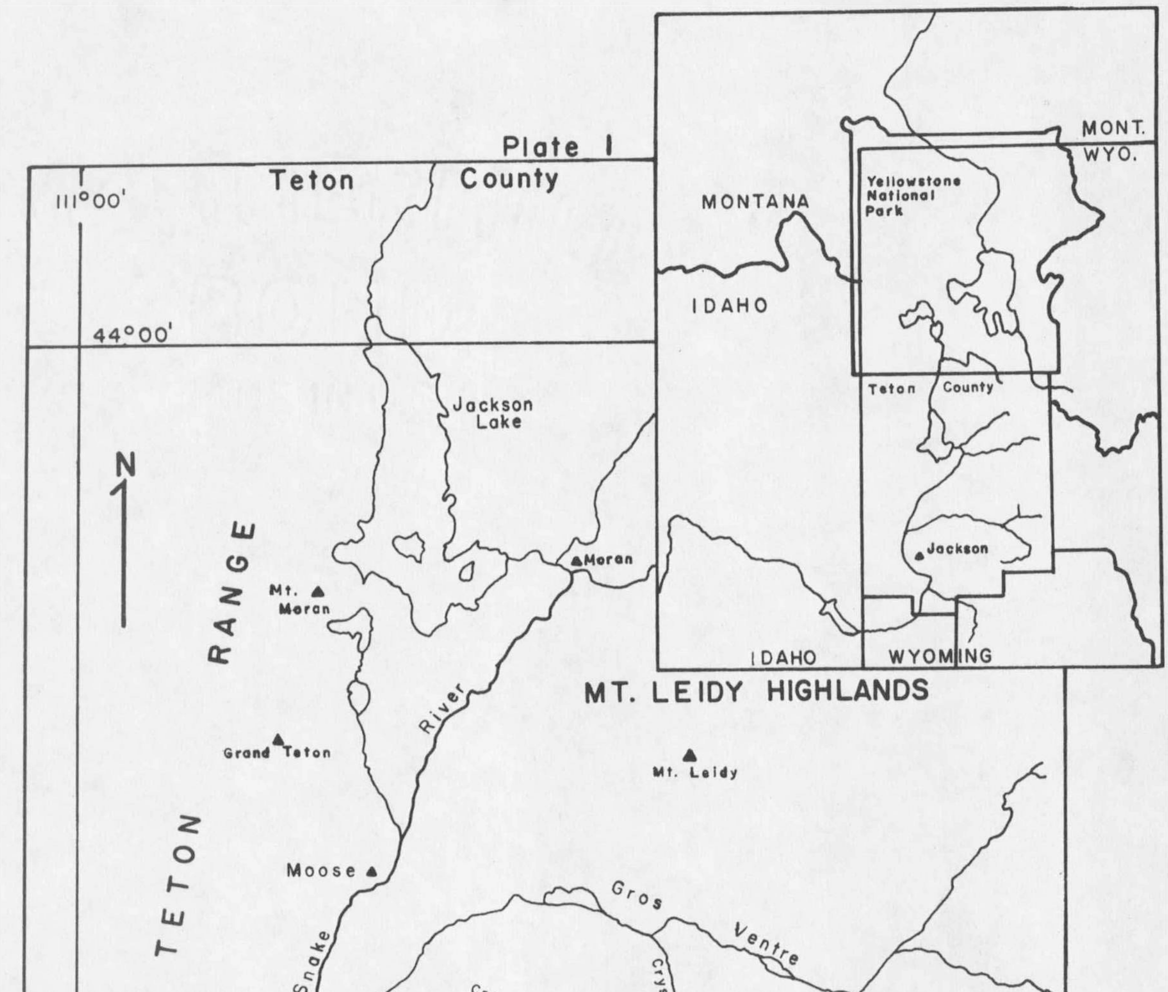
Location and Access

The area under study involves approximately 26 square miles in the Gros Ventre Range of Teton County, Wyoming, and is located mainly in T. 40 N., R.'s 114 and 115 W. (unsurveyed). A minor portion overlaps into T. 41 N., R.'s 114 and 115 W. (unsurveyed). It forms a major section of the southwestern backbone of the Gros Ventre Range, lying on the drainage divides between Flat, Granite, and Horse Creeks, and Nowlin, Flat, and Cache Creeks. Most of the area lies above 8,000 feet, the highest peaks rising to just over 11,000 feet (Plates 1 and 5).

Access is primarily by National Forest Service horse trails which follow most of the major creeks. Two other high altitude trails are usable. These routes can be reached by four non-graded roads in Teton County. The first and most feasible is in the bottom of Cache Creek to the west; second, from a logging road north of Jackson Peak; third, from the Granite Creek recreation road; fourth and least advisable, the Flat Creek road. All but the fourth access road may be driven by ordinary automobile during July and August, and all lead to various trail heads whereby access to the area or specific sections thereof may be gained.

The area is of rugged alpine terrain, and is relatively snow-free from early July through early to mid-September. Good campsites are available almost anywhere with excellent water and wood. Forage for pack animals is only locally plentiful.

Plate I



LOCATION MAP

Hachured region denotes extent of thesis area

Purpose

The major objective of this study is to produce a detailed geologic map of the area surrounding the headwaters of Nowlin, Flat, and Granite Creeks in Teton County, Wyoming. Because most previous work in this region has been of a reconnaissance nature, a complete explanation of the structure and associated problems is necessary. A lesser objective was to measure a section for general comparison with work done in surrounding regions. It is also intended to summarize the geomorphology of the area based on reconnaissance work, as well as to report other points of interest to the future researcher.

Method

During the summer of 1967, a total of 7½ weeks were spent mapping the geology in the field. An additional 2½ weeks of similar field work was accomplished in the same area during the summer of 1965 for an undergraduate thesis (Love 1966). The present thesis is a rigorous expansion and modification of the earlier work. Field work was done from 2 base camps in 1965, and an additional 4 camps in 1967, spending from 4 days to 2 weeks in each one.

Geologic mapping was accomplished on U.S. National Forest Service aerial photographs, of 1/25,000 scale, and subsequently transferred to advance proofs of the U.S. Geological Survey 1/24,000 quadrangles issued in 1966. The area currently lies in the Jackson 1 NW quadrangle and the Jackson 1 NE quadrangle (now possibly changed to the Turquoise Lake quadrangle).

The stratigraphic sections were measured by the tape and compass method, and the following field descriptions were based on handlens and acid bottle techniques.

All photographs were taken with Kodachrome II color film on a Voigtlander Vitessa 35 mm camera.

Previous Investigations

Orestes St. John (1879, 1883) accomplished the first significant geological observations of a large region in northwestern Wyoming known as the Teton Division, wherein is contained the study area. Indeed, a number of his observations were made from two peaks within the thesis area and some of his evidence has been completely overlooked by all subsequent investigators. Although a great many of his interpretations are now known to be incorrect, the sheer volume of description and resulting correct inferences made is most remarkable. The next researcher, Eliot Blackwelder (1915, 1918) worked on a regional scale and made his closest observations 15 miles to the east, where he measured what is now a standard comparative section.

Since then only five significant published works have been presented which deal in any detail with the area under study. Nelson in 1942 produced a paper entitled "The Structural Geology of the Cache Creek Area, Gros Ventre Mountains, Wyoming" involving the western half of the thesis area. This was expanded in 1943 with Church to include the gross structures of the Gros Ventre and northern Hoback Ranges. Horberg, Nelson, and Church then produced another general paper on the structural trends of Central Western Wyoming in 1949, the Gros Ventres playing a major part. The fourth publication is a somewhat generalized thesis by Swenson, also in 1949, on the northern flank of the Gros Ventre Range. His area lies several miles to the north of the present thesis area. He was not concerned with what happened outside his area to the south, but certain observations were made which are helpful to this study. Some of his stratigraphic sections, it should be noted, are only estimated thicknesses. Van Dyke (1956) has done the work of most importance to this thesis. His research on the structure of the upper Horse Creek area directly involved a portion of the present study, and it is to his intriguing paper that some of the present writer's work will be compared. Eugene Blasdel, a University of Michigan graduate student, is currently mapping a similar area to the southeast. He plans to overlap the present thesis area as far west as Turquoise Lake (personal communication, July 1968).

Stratigraphic work has been non-existent within the thesis area, with the exception of two workers who have measured sections there: Miller (1936), and Denson (1942). Those more important researchers measuring or compiling nearby sections which would pertain to the thesis area are Blackwelder (1918), Miller (1936), Foster (1947), Shaw and Deland (1955), Wanless and others (1955), Lochman-Balk (1956), Benson (1966). Although a multitude of observers have contributed to the stratigraphic picture, including confusion of names, these works have calculated thicknesses and descriptions of importance to the thesis area.

There has been no previous work done in the study area on its geomorphic aspects, however Blackwelder (1915) has studied the Gros Ventre River terraces, glacial deposits, and high altitude erosion surface to the north, with regional conclusions in mind. Swenson (1949) recapitulates a few of these.

The only economic aspect of the thesis area that has been realized or utilized are some iron ore claims which have been filed to the east in the Amsden Formation. No action other than claim staking has been taken.

GEOMORPHOLOGY

Description of Area

The Gros Ventre Range consists of several broadly uplifted and faulted anticlines trending northwest-southeast. The present crests range from 10,000 - 11,500 feet in elevation, with several outcroppings of the Precambrian core along the southwest-thrust flanks. The original elevation of the range, created during late Laramide time, is difficult to estimate as broad eroded areas presently exist above 10,000 feet and the erosional history is unique. Canyons dissecting the range are deep and have undergone intense glacial modification. Cirques are common. The present relief of the thesis area is slightly over 3,000 feet.

Sequence of Events

The oldest geomorphic feature is an immense erosion surface, on which the highest peaks of the range seem to form monadnocks. This surface, only partially included on the north border of the thesis area, extends over much of the range to the north and east. It probably covered the study area at one time. Great undulating flat expanses at an approximate average elevation of 10,500 feet and evenly beveling all strata characterizes this surface. Only two workers have examined this surface in reconnaissance: Blackwelder (1915), and Swenson (1949). Although Blackwelder (1915) mentions this surface under his Union Pass erosion cycle, its features and latitude places it on a par with his Fremont erosion cycle, completed near the end of the Pliocene. However Swenson (1949), whose area overlapped part of this surface, agrees with

Blackwelder in his interpreting it as Union Pass. It does not appear to have been affected by glacial action other than in the cirques eroding into it on all sides. Any ancient stream pattern is unrecognizable, at least from the ground. To the south, many of the Hoback Range peaks just reach the altitude of the erosion surface. None are above it. Similar surfaces exist to the north in the Absaroka Range, to the east in the Wind River Range, and to the south in the Uinta Range.

A conglomerate was found on one of the drainage divides at an elevation of 10,400 feet, and as this has not been described before in the stratigraphy of northwestern Wyoming, its placement suggests several possibilities as to origin. As it overlies the Pennsylvanian Darwin Sandstone, it could be a purely local conglomerate of that age. However, no nearby sections report any conglomerate. This particular one is more than 50 feet thick and has well-rounded late Paleozoic pebbles up to and slightly over an inch in diameter. Its location, size, and composition intimate that it was eroded from a nearby source of Paleozoic strata in which the Precambrian was not yet exposed. Such a situation could have occurred during the cycle of erosion creating the high level surface.

At a date later than the beveling of the Gros Ventre surface, a stream pattern was briefly established on this surface. Because most of the present major drainages originating in the Gros Ventres turn approximately 180° from their source before emptying into another major drainage system, alteration of the original pattern is suspected. Flat

Creek, Granite Creek, and the Gros Ventre River all flow a short distance northeasterly from their source. The other major drainage, Crystal Creek, flows slightly west of north (Plate 1). Most of the tributaries flow in similar directions. Flat Creek, Crystal Creek, and the Gros Ventre River all eventually circle to the west via north, and flow into Jackson Hole. Granite Creek, the one odd exception, flows west by circling around to the east, then south, and finally into the westward-bound Hoback River (Plate 1). The original northeast oriented pattern is suggestive of streams flowing down the dip of the broad northeast flank of the Gros Ventre anticlines. The present pattern is generally indicative of a gradual regional tilting towards Jackson Hole to the west and southwest (Love and Montagne, 1956). These drainages are all affected by faults or flexure zones, although Flat, Granite, and Crystal Creeks are affected only for a small part of their downstream courses. How crucial these sections are to the drainage pattern, particularly that of Granite Creek, will be determined only by much more extensive field work.

The top of the glacially steepened walls in the canyons of the thesis area averages 9,000 feet in elevation. This is 1,200 to 1,600 feet lower than the erosion surface. Thus, these few drainages and their tributaries appear to have deeply dissected the erosion surface before ice helped to modify their canyons.

The pre-glacial streams undoubtedly eroded their way to the Precambrian, for much of the basement complex exposed has the appearance and topography of having been recently stripped of its sedimentary cover. The ensuing glacial erosion has modified the Precambrian only to the point of having created several horn-like peaks along the major, jagged, northwest-trending ridge.

That these mountains have been glaciated more than once is most readily evidenced on the southwest side of the Gros Ventre front in the thesis area. Here there is displayed debris from at least two glaciations which have been mapped as Qg_1 and Qg_2 respectively. Evidence is strong in surrounding regions of at least three glaciations (Montagne 1956; Love 1956). Qg_1 becomes more obvious to the east along the mountain front, for it is extremely widespread and covers all of the near drainage divides south of the mapped area. To the west, however, it is not so ubiquitous and appears to have rather sharp boundaries. In general it is characterized by sporadic large rounded boulders of Precambrian material, and exhibits its thin cover in what little hummocky topography is visible.

Qg_2 is restricted to most of the narrow valley and gully openings in the front of the range. There are many Precambrian boulders and hillocks of debris contained for a short distance within these valleys, none extending more than two miles from the range front. Its fresh appearance and sharp boundaries intimate that it is the younger of the two, there being no overlying debris other than protalus and recent rock glaciers in the cirques of their origin. Loess, which characteristically overlies much of the glacial debris in Jackson Hole, was not noticed. High rates of erosion in this rugged topography have probably never allowed it to accumulate.

On the northeast side of the range crest, there was no immediate and obvious indication of more than one glacial stage, although several must have existed. Most of the valley surfaces have been scoured clean, grooved, and polished by the most recent ice. Only a veneer of fresh debris exists on the canyon rims down stream from the most recent erosional products. In the valleys too, only thin deposits and a few low mounds are evident. With one possible exception, no terminal or recessional moraines were found within the thesis area. As a result, the most recent extensive glacial debris, whose upper limits could not be determined on valley walls, was not mapped on the northeast side of the range front. It did not appear to cover the major northeastern drainage divides except in the area of their headwaters. Striations or debris were found extending completely across the divides between Sheep and Flat Creeks, Flat and Cache Creeks, Flat and Granite Creeks, and Granite and Bunker Creeks. Ice also passed to the south over the major Precambrian ridge west of Pinnacle Peak. Although no other direct indications were observed elsewhere, this ridge is low enough in several places for ice to have easily passed southward. The result of the valley glaciations has transformed the major drainages into the typically broad U-shaped canyons common to alpine glaciated regions.

A single moraine of uncertain origin was found near the toe of the northern-most glacial-landslide debris mapped on the western wall of

Flat Creek. Located at an elevation of 9,280 feet, it is more than 10 feet high, parallel to Flat Creek canyon, and nearly reaches the canyon edge. Three origins seem possible, although the first appears least attractive. It could be a recessional moraine to a small cirque area existing to the west. Its straightness however, hints at a lateral moraine for ice within Flat Creek canyon. As a third possibility it could be a medial moraine between ice in the small western cirque and that in Flat Creek canyon. Either of these last two cases necessitate at least 1,000 feet of ice in Flat Creek canyon. This may have been the situation at one time, for two miles to the southwest there are striations 80 feet above the bottom of the talus on the eastern vertical wall of Jackson Peak, near the Sheep Creek - Flat Creek divide. That this much ice was moving down Sheep Creek at this point rather than into the more precipitous Flat Creek canyon may mean that the latter area was full. It is improbable that ice would have moved in the opposite direction due to the orientation of minor Sheep Creek headwalls. Hence the case for a lateral or medial moraine on the wall of Flat Creek canyon is built. There are undoubtedly others along the tributaries to these main drainages, but specific field work and research will be needed to work out the entire story.

The age of the recent glacial action on the northeast side of the main Gros Ventre ridge must certainly have been Pinedale. Terminal moraines in the mouths of some of the drainages outside the area are considered to be of that age (Montagne 1956: Love 1956). The writer suspects that Qg_2 along the south side of the ridge is Pinedale as well, due to its small, fresh, and limited extent. Extreme exposure to radiation accounts for its lesser development in comparison with other known Pinedale glaciers with northeast exposures.

The last glacial epoch may not have left the Gros Ventre Range entirely, for there are frequent rock glaciers, several with cold late summer streams emanating from them. Four of these are located to the north of the main ridge, and one to the south. All but one northern rock glacier exist in protected downwind positions. Only the southern rock glacier faces southeast, all others in northerly directions. The accumulated debris is generally semicircular in shape, rarely exceeding 200 yards across. They may represent a 'last gasp' of the Pinedale substages.

Related to remaining ice are features mapped as glacial-landslide material. In these cases it was impossible to determine whether the flow had been the result of just gravity, or had been aided by the presence of ice. All of these questionable areas involved the Cambrian shales and limestones, and hence the reverse could be true, glacial action could have been aided by the presence of these incompetent strata. The action has been different on the glacial-landslide debris of the Flat - Cache Creek divide and at the head of Nowlin Creek than it has on the two areas on the west wall of Flat Creek Canyon. The Cache Creek and Nowlin Creek glacial-landslides were probably the result of ice spilling over the divide from Flat Creek. As the Cambrian limestones and shales outcrop along these respectively folded and faulted areas, flow-landsliding began taking place during and after the ice melted. That ice went through the divides is proven in the Flat-Cache Creek case by glacial debris 100 feet above the saddle of the divide to the north. Both areas display great hummocky topography including juxtaposed house-sized blocks. Additional sliding from a source area does not seem important.

By contrast, the two glacial-landslides on the west wall of Flat Creek canyon are much fresher in appearance, the process probably still continuing. These both were started by ice in minor cirques, which began to form a headwall in the comparatively soft Cambrian rocks. The ice then melted away, helping to "lubricate" the basal shale on which all the debris has since crept down slope. The landsliding process still continues with great blocks of Ordovician dolomite spalling away from the headwall and riding down a dip slope of Cambrian shales.

One landslide area which was mapped as such is on the Granite-Flat Creek divide. In this case, a major portion of Cambrian limestone has been weakened at the bottom of a dip slope by a small fault. With the subsequent removal of support, the limestones have slid by degrees on the shales beneath. The thinness of the slide cover hints at the possibility that ice was not present, although a distinction made on this basis may not be valid.

In the head of the Granite Creek area, a gravity slide block of competent Cambrian quartzite moved prior to the most recent glacial epoch. Sliding north and rotating slightly, it came to rest at a point just above the canyon bottom, and was subsequently covered with glacial debris.

The only other ice or snow related features are the protalus ramparts accumulating in various areas. These are numerous but rarely extensive, and commonly grade into present talus slopes or appear to be remnants of some other precipitation cycle. No attempt to establish relationships to rock glaciers or talus slopes was made.

The last glacial epoch ended so abruptly in the thesis area, that talus slopes are just beginning to form in some areas. The ice, while present, tended to erode the Paleozoic strata off the Precambrian, leaving a narrow bench around the upper ends of the canyons. It is on this bench that the Cambrian Flathead Quartzite is forming extremely active talus slopes. While in some areas almost no talus has formed, in others talus is proceeding at so rapid a rate that the soil is being peeled back by the thrust of the moving blocks. It appears that point-contact pressure between the angular blocks is applied, bulldozing the soil into a mound as much as two feet high in front of the rocks (Figure 1). The rate of movement certainly exceeds the rate of soil erosion in these areas.

The present topography is only a slight modification of that which existed during the glacial stages. Erosion has not proceeded long enough to eradicate the thin cappings of basal Cambrian quartzites from the highest peaks. St. John (1879, 1883) noted Flathead Quartzite on Jackson Peak and on the highest peak (unnamed) in the main ridge. The writer found and mapped 40 feet of this formation on a third peak as well, having found 75 feet on Jackson Peak, and 8 feet on the highest