American Journal of Science

JUNE 1942

PRE-CAMBRIAN METASEDIMENTS IN GRAND TETON NATIONAL PARK, WYOMING.

LELAND HORBERG AND FRITIOF FRYXELL.

ABSTRACT. Metamorphosed sediments, largely quartzites, occur within the gneissic complex of the Teton Range at scattered localities. Except for two sections, the sediments are thin and restricted in extent. The quartzites grade into banded gneisses, the characteristic rock type of the range, and probably represent remnants of what may have been a common country rock prior to batholithic intrusion and metamorphism.

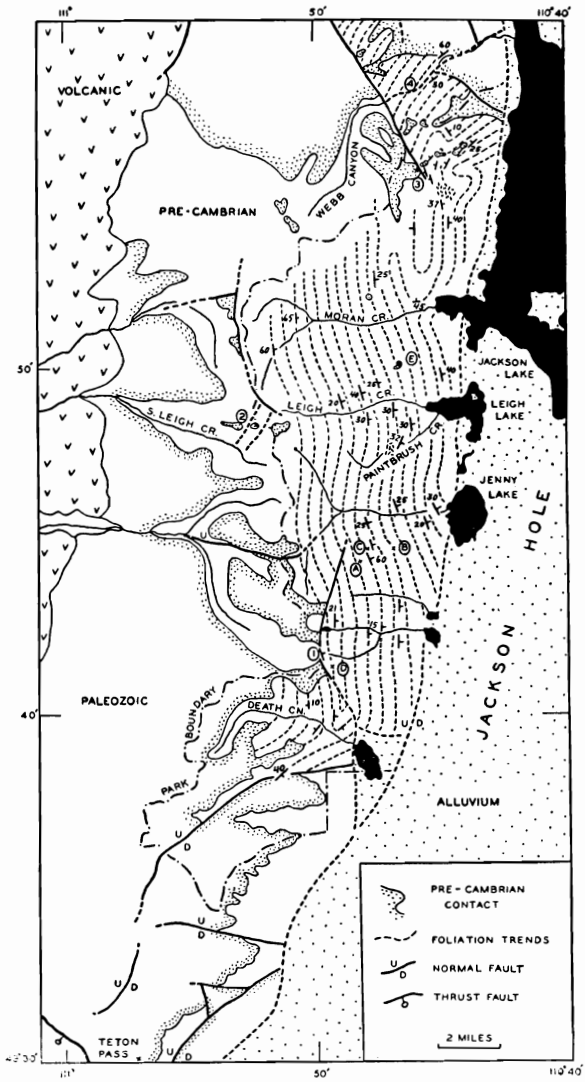
INTRODUCTION.

DESPITE growing interest in the Teton Range as a scenic and mountaineering area little is known regarding the pre-Cambrian rocks forming the spectacular alpine summits of the range. This lack of knowledge is not peculiar to the Tetons, but is a reflection of general neglect of pre-Cambrian problems in the Middle Rocky Mountains. During the past ten years the writers have had the opportunity of examining most of the Teton crystalline area. Observations were incidental to other studies and no detailed work was attempted. The present paper is intended to call attention to scattered occurrences of metamorphosed sediments within the prevailing gneissic complex and to point out relations which may stimulate interest and lead to further study.

GENERAL CHARACTER OF THE PRE-CAMBRIAN.

Although the persistent gneissic and schistose character of the Teton crystalline rocks was early noted by members of the Hayden Surveys,[1] a popular misconception has arisen regard-

[1] Bradley, F. H.: 1873, "Geological Report of the Snake River Division," *Sixth Ann. Rept. of the U. S. Geol. Surv. of the Terr.*, pp. 216-17.
St. John, Orestes: 1879, "Geological Report of the Teton Division," *Eleventh Ann. Rept. of the U. S. Geol. Surv. of the Terr.*, pp. 474-75.



Text Fig. 1. Map showing pre-Cambrian structure, Grand Teton National Park, Wyoming. (1) South Avalanche Canyon locality; (2) Little's Peak locality; (3) Ranger Peak locality; (4) Webb Canyon locality; (A) Grand Teton; (B) Mt. Teewinot; (C) Mt. Owen; (D) Buck Mountain; (E) Mt. Moran.

ing the common rock types present. Numerous accounts including at least two recent texts have referred to the range as granitic even though the peaks exhibit few of the regularities of a granite area. Instead the bristling skyline for which the range is famous is a reflection of steeply dipping crystalline foliates which control much of the morphologic detail (Plate 1, Fig. 1). So striking is this influence that the Tetons may well be regarded as a type example illustrating the control of tilted and sheared metamorphic foliates on rugged alpine topography.

The areal extent of the pre-Cambrian rocks (Text Fig. 1) roughly coincides with the boundaries of Grand Teton National Park and includes the highest portion of the range. Along the precipitous east mountain front almost continuous exposures are found from Teton Pass on the south to Berry Creek on the north, a distance of 36 miles. Exposure of the crystalline rocks here is due largely to uplift along a high angle Tertiary fault following the base of the range. Laramide folds preserved on the backslope of the fault block are revealed by branching of the crystalline core near the head of Moran Canyon. At this locality the pre-Cambrian rocks are exposed across the entire width of the structure in a belt 13 miles wide.

Throughout the crystalline area the characteristic rocks are granitic gneisses with inclusion-like masses and intercalated layers of hornblende and biotite schist. These have been complexly intruded by masses of granite and pegmatite which range in size from small stringers to stock-like bodies a fraction of a mile in diameter (Plate 1, Fig. 2). Intrusive phenomena are so intensive and persistent over wide areas that much of the pre-Cambrian complex is regarded as being within the roof zone of a granite batholith. This interpretation seems particularly applicable to the central, alpine area, where intrusives are most abundant and extensive, and most complex in their relationships. In general at the extremities of the range the older schist complex shows fewer intrusions and less extensive gneissic areas. On Buck Mountain there is widespread mica, chlorite, and actinolite schist and in lower Webb Canyon the dominant rock is hornblende schist (Text Fig. 1). The youngest intrusives are undeformed, nearly vertical, diorite dikes which strike west-northwest across the trend of the range. They are conspicuous features on some of the major peaks, notably Mount Moran,

Grand Teton and Middle Teton, on these peaks following joints of the east-west master set. The metaquartzites and conglomerates to be discussed occur within the gneissic complex and in total bulk are of slight importance. Although detailed studies will doubtless reveal several ages of country rock and intrusives, the general relations appear to be:

Basic dikes
Granite and pegmatite
Granitic gneiss; schists; metaquartzite

The general structure shown by foliation trends in Text Fig. 1 reveals a dominant north-south strike paralleling the range and east dips varying from 20 to 65 degrees. The widespread persistence of this structure is noteworthy. However, in detail there is such great structural and intrusive complexity that only large scale mapping of small areas would give adequate representation. The trends indicated are thus averages for respective areas. Small-scale folding and shearing accompanied by numerous local reversals of dip are especially prominent near intrusives (Text Fig. 2). However, many dikes cut across the older structure and modify it little or not at all. Important departures from the normal east dip occur along Death Canyon (Text Fig. 1) where the foliation dips gently to the west and within the salient north of Mount Moran (Text Figs. 1 and 2). In the latter area a broad anticline trends north into a faulted sector where the strike swings to the northeast.

METAMORPHOSED SEDIMENTS.

Little's Peak.—The summit and west slope of Little's Peak (Text Fig. 1, locality 2) is formed by a pre-Cambrian quartzite which Rudolph Edmund,[2] describes as a "sugary" quartzite and quartzite-conglomerate, for the most part pure white but in places shading into pink, green or brown (Plate 2, Fig. 1). Where conglomeratic it contains well-rounded pebbles and boulders ranging up to three feet in diameter. In many places the rock is brecciated and much sheared, with resulting obliteration of sedimentary structures. The quartzite strikes about N. 70° E. and dips steeply north-northwest. Shear planes are parallel to bedding, and in places produce good cleavage. The

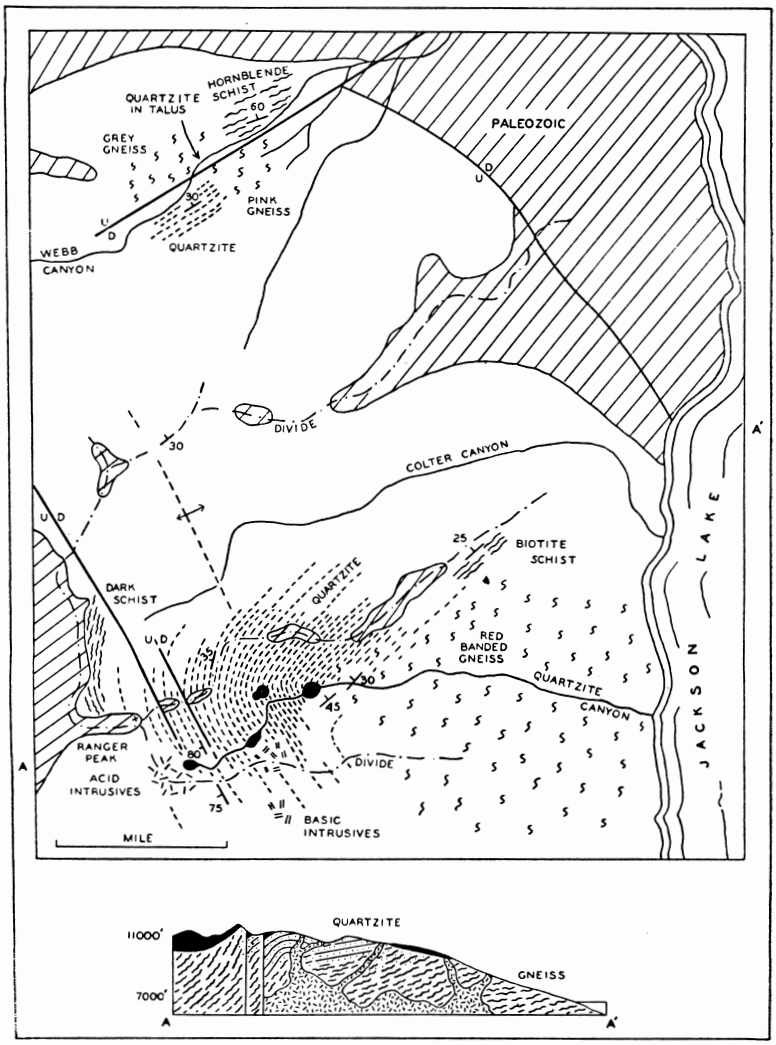
[2] Personal communication.

talus of the south wall of South Leigh Canyon includes rock of this type, and quartzite is also present on the Badger-Jackpine divide, though here no conglomerate was noted.

South Avalanche Canyon.—In this area the pre-Cambrian consists largely of grey, banded gneiss which has been intruded by the persistent granite and pegmatite. The intrusives appear intricately interwoven with the country rock completely isolating large masses of gneiss and schist. Xenoliths are abundant in the larger granite areas and much of the gneiss appears to be of injection type. Associated with the gneisses are hornblende, biotite and chlorite schists in smaller amounts. At the lowest and most accessible point in the saddle between South Avalanche Canyon and Alaska Basin a thin bed of metaconglomerate is preserved within the gneissic complex (Text Fig. 1, locality 1). The bed is about a foot thick, strikes N. 19° W., and dips 47 degrees east. The conglomerate has been sheared and brecciated, but the rounded outlines of cobbles up to 9 inches in diameter are clearly recognizable (Plate 2, Fig. 2). Sorting is poor and the matrix fine-grained so that superficially the rock resembles a tillite. However, there are no other glacial characters which support this origin. The immediate area is less complex than most of the range and has distinctive lithologic units which may prove mappable on large scale.

Ranger Peak.—Possibly the best preserved section of sediments within the pre-Cambrian is exposed on the east ridge of Ranger Peak and the adjoining area to the north (Text Fig. 2). Here a section of quartzite 1650 to 1850 feet thick forms a strike ridge that trends N. 25° E. and dips 35 to 80 degrees northwest. The quartzite is white, grey or pink, conspicuously banded with dark minerals in layers 1/16 to 1 inch thick. This lithology dominates throughout the section, although thin beds of phyllite, biotite schist, chlorite schist, and garnet schist were noted. Drag folds are conspicuous in the foliates; otherwise the original bedding is essentially undisturbed. Foliation is of the bedding plane type and is shown by the presence of phyllite and schist derived from fine grained sediments and by the recrystallization of the dark minerals of the quartzite into biotite.

The sediments have been cut by sills and dikes of coarse, red granite and pegmatite, 3 to 30 feet thick, and at one locality by basic intrusives. Near granite intrusives the quartzite is locally



Text Fig. 2. Map and cross section showing pre-Cambrian structure and lithology in the Ranger Peak-Webb Canyon area. Foliation trends are shown by dashed lines, normal faults by heavy solid lines, and the axis of a Laramide fold by a broken line with dip symbol.

altered to banded injection gneiss with transitional phases of quartzitic gneiss. This assumes special significance in considering the relation of the quartzite to adjoining rock of the crystalline complex, which is largely pink, banded gneiss. This gneiss shows transitional phases from contorted, banded gneiss to bedded quartzite suggesting that a large part of the adjacent complex could have been formed by injection and related processes. That the quartzite is *within*, rather than above, the gneissic complex is further evidenced by dark colored schist which occurs stratigraphically higher than the quartzites along the ridge north of Ranger Peak (Text Fig. 2). The contact of the quartzite with the overlying Flathead sandstone (Middle Cambrian) is marked by an angular unconformity with an arkosic basal conglomerate of angular quartz fragments.

Webb Canyon.—Along Webb Creek, three miles above its junction with Berry Creek, quartzite outcrops at the base of the south wall of the canyon (Text Fig. 2). This quartzite also is believed to lie within the pre-Cambrian complex, as typical pre-Cambrian metamorphic rocks occur immediately north of the outcrop (grey gneiss) and northeast of it (pink gneiss). No evidence of local faulting was found, and these metamorphic rocks, at least in part, are probably stratigraphically higher than the quartzite, as the regional structure involves a strike of N. 60° E. and a dip of 30° N.W. (The Webb Canyon fault is thought to lie just north of the area in question.)

The quartzite extends up the south wall at least 200 feet, and may continue to the top, as the crest has the appearance of a strike ridge like that east of Ranger Peak. This section may, therefore, have a thickness equal to or exceeding that of the Ranger Peak area (1650′–1850′). Colter Canyon was not explored, but the discovery of quartzites here may be expected in view of its position midway between the Ranger Peak and Webb Canyon sections.

The quartzite noted in Webb Canyon is white to pink, and of massive structure. It lacks the associated dark minerals and banding so conspicuous in the quartzite near Ranger Peak. Large masses of pink quartzite fallen from positions higher on the south wall suggest that this is the prevailing rock type.

It is noteworthy that downstream from this outcrop there occurs a pink quartzose gneiss, very similar to that in the

Ranger Peak area. However, a rapid transverse of the canyon did not reveal any transitional types.

Quartzite must also be present within the north-wall section, as fragments of white and grey quartzite were found in talus at the base of the north cliffs.

Other Localities.—In many places occur well-banded gneisses with sharply defined layers an inch or less thick of white quartzose rock—in some instances typical quartzite—alternating with dark schists (biotite or hornblende). The distinctness of these layers, the fact that they are not closely related to any intrusives and show relatively little evidence of metamorphism, and the persistence of the layers through hundreds of feet with scarcely perceptible change of thickness, support the view that these rocks were derived from sediments and that their banding is a reflection of stratification. Rocks of this type may be conveniently examined along the trail about a mile up Paintbrush Canyon, and, higher, on the upper west slopes of Mount Woodring.

Rocks less certainly referable to the category of metasediments have been noted in the pre-Cambrian complex of the alpine region: at altitudes of 11,000 to 12,000 feet on Teewinot, Mount Owen, Mount St. John, and Bivouac Peak. In these instances the rocks are an unbanded quartzose type, white to grey, lacking the "sugary" or granular texture of typical quartzites. They occur as layers only a few feet thick in the gneiss-pegmatite complex, or are known only from scattered boulders. They may be rocks impregnated with silica from a magmatic source, or, in some cases, metamorphosed quartz veins.

CORRELATION.

The type locality of the Sheridan quartzite is in Yellowstone National Park, less than 25 miles north-northeast of the Ranger Peak and Webb Canyon sections. Although referred to the Algonkian, the exposures are restricted by lava cover and relations of the quartzite to the gneissic system uncertain.[3] Similar quartzite is reported by Anders Bengston[4] from the canyon of the north fork of Buffalo Creek, 30 miles east of Ranger Peak. Although these sediments may well be younger

[3] Hague, Arnold: 1896, "Yellowstone National Park Folio, Wyoming," *U. S. Geol. Surv. Geol. Atlas*, Folio 30.

[4] Personal Communication.

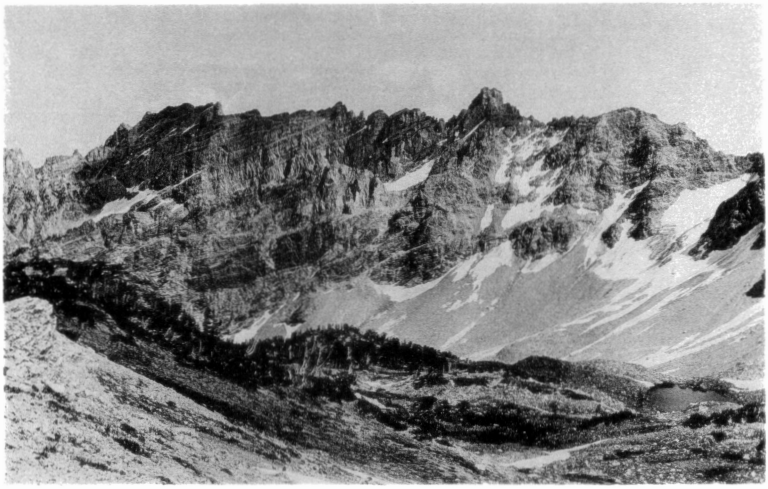


FIG. 1. South wall of Indian Paintbrush Canyon showing the prevailing east dip of foliation found throughout the range. The jagged skyline is a reflection of metamorphic structure and joints. Photo by Kenneth A. Henderson.

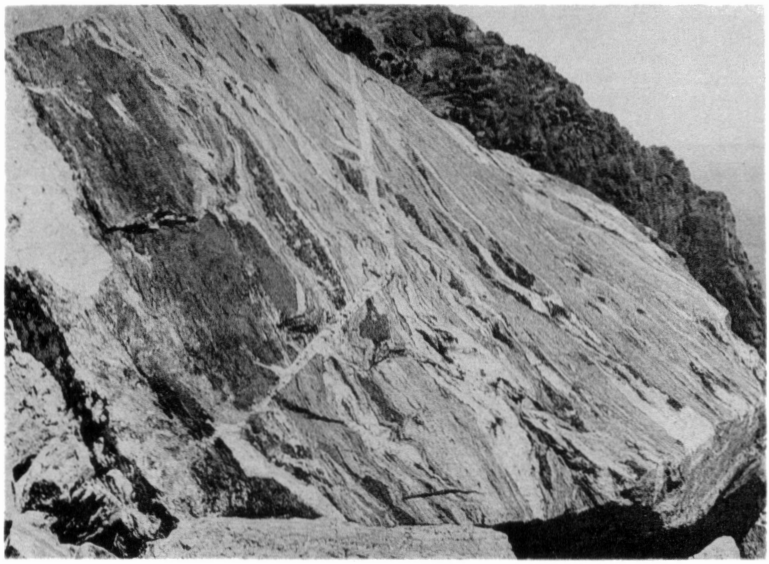


FIG. 2. Gneissic complex showing banded gneiss, schist and granite stringers; Cascade Canyon. The exposure is about 20 feet wide.

FIG. 1. Quartzite conglomerate on the west slope of Littles Peak near the summit (Locality 2, Fig. 1). Photo by Rudolph Edmund.

FIG. 2. Sheared and metamorphosed conglomerate at the head of South Avalanche Canyon (Locality 1, Fig. 1).

than those of the Teton Range, the possibility of equivalence must be considered.

The pre-Cambrian rocks of Utah and Wyoming have been described by Blackwelder[5] in terms of three groups of contrasting rock types: (1) a quartzite-slate system, probably of Beltian age; (2) a metaquartzite and schist system of intermediate age, best represented by a 12,000-foot section in the Medicine Bow Range and by the Cherry Creek series of the Gravelly Range, Montana; (3) an ancient gneissic system well developed in the Laramie, Big Horn, Wind River, and Teton ranges. The gneissic system is described as a complex of contorted gneiss, usually biotite, intruded by batholithic masses of granite which are often gneissoid. There is no question but that the crystalline rocks of the Teton Range are to be included within this lithologic group and the quartzites noted above may thus represent one of the oldest sedimentary series thus far reported from the Middle Rockies.

Until much more detailed work has been done there is little assurance that lithologic type and even intrusive relations reflect stratigraphic sequence, and the crystalline rocks in the Teton Range may be older or younger than those in other similar gneissic areas.

ACKNOWLEDGMENTS.

The writers are indebted to the officials of Grand Teton National Park for willing coöperation during many field seasons and to the Geological Society of America for a grant from the Penrose Bequest during the summer of 1941. Rudolph Edmund kindly made available an unpublished geological map of the north end of the Teton Range from which certain data were taken for Text Fig. 2. The manuscript has profited through critical reading by T. T. Quirke and Carleton A. Chapman.

[5] Blackwelder, Eliot: 1935, "Summary of the pre-Cambrian Rocks of Utah and Wyoming," *Utah Acad. of Sci. Proc.*, Vol. XII, pp. 153-57.

UNIVERSITY OF ILLINOIS,
AUGUSTANA COLLEGE,
ROCK ISLAND, ILLINOIS.