

Proterozoic Geology of the Granite Village Area, Albany and Laramie Counties, Wyoming, Compared With That of the Sierra Madre and Medicine Bow Mountains of Southeastern Wyoming

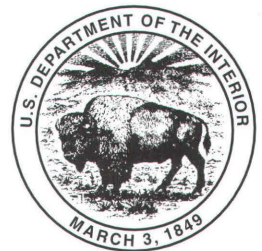
U.S. Geological Survey Bulletin 2159

U.S. Department of the Interior
U.S. Geological Survey

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By Robert S. Houston *and* Gordon Marlatt

U.S. GEOLOGICAL SURVEY BULLETIN 2159



UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1997

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

For sale by U.S. Geological Survey, Information Services
Box 25286, Federal Center
Denver, CO 80225

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Library of Congress Cataloging-in-Publication Data

Houston, Robert Stroud, 1923—

Proterozoic geology of the Granite village area, Albany and Laramie counties, Wyoming,
compared with that of the Sierra Madre and Medicine Bow mountains of southeastern
Wyoming / by Robert S. Houston and Gordon Marlatt.

p. cm. — (U.S. Geological Survey bulletin ; 2159)

Includes bibliographical references (p. —).

Supt. of Docs. no.: I 19.3:2159

1. Geology, Stratigraphic—Proterozoic. 2. Geology—Wyoming—Albany County.
3. Geology—Wyoming—Laramie County. I. Marlatt, Gordon. II. Title.

III. Series.

QE75.B9 no. 2159

[QE653.5]

551.7'15'097871—dc20

96-31566

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Proterozoic Geology of the Granite Village Area, Albany and Laramie Counties, Wyoming, Compared With That of the Sierra Madre and Medicine Bow Mountains of Southeastern Wyoming

By Robert S. Houston¹ and Gordon Marlatt²

ABSTRACT

Precambrian metavolcanic rocks north and south of the village of Granite, Wyoming, belong to a sequence of isolated metavolcanic and metasedimentary masses in the Sherman Granite of the southern Laramie Mountains. Similar rocks lie to the west, in the Precambrian uplifts of the southern Medicine Bow Mountains and Sierra Madre. A major fault system, the Cheyenne belt, splits these two ranges into northern and southern domains, and may constitute a suture along which Early Proterozoic island arcs collided with an Early Proterozoic passive margin. Projection of the Cheyenne belt into the Laramie Mountains suggests that the study area, which is 65 kilometers south of the proposed suture, comprises a distinct volcanic arc with a unique chemistry or age. However, chemistry of the volcanic rocks of the study area as determined so far does not differ significantly from those of the Medicine Bow Mountains and Sierra Madre.

INTRODUCTION

Precambrian metavolcanic rocks are exposed in a northeast-striking body, approximately 7 km wide and 20 km long, north and south of the village of Granite, Wyoming (fig. 1). These metavolcanic rocks are part of a sequence of metavolcanic and metasedimentary rocks that occur in isolated masses within the extensive body of Sherman Granite of the southern Laramie Mountains (fig. 1). These metavolcanic and metasedimentary rocks were first mapped and described by Eliot Blackwelder (Darton and others, 1910). They were described briefly in a study of the Sherman Granite by Harrison (1951), and a detailed study of a 5 km² area in the center of the outcrop was reported by King and Parker (1966).

Study of the Granite Village area was begun by one of the authors (Houston) in 1984 as a part-time undertaking during the final phases of our study of the Sierra Madre (Houston and Graff, 1995). The Granite Village area was mapped when time constraints or weather did not allow us to work in the Sierra Madre, which is located more than 160 km west of our Laramie, Wyoming, headquarters. The Granite Village area could be studied on day trips because it is located some 50–65 km east of Laramie. This sporadic mapping by Houston was done over a long period from 1984 to 1991. Marlatt undertook a study of the area in 1981–1989, in part to evaluate the use of remote sensing techniques in volcanic terrain.

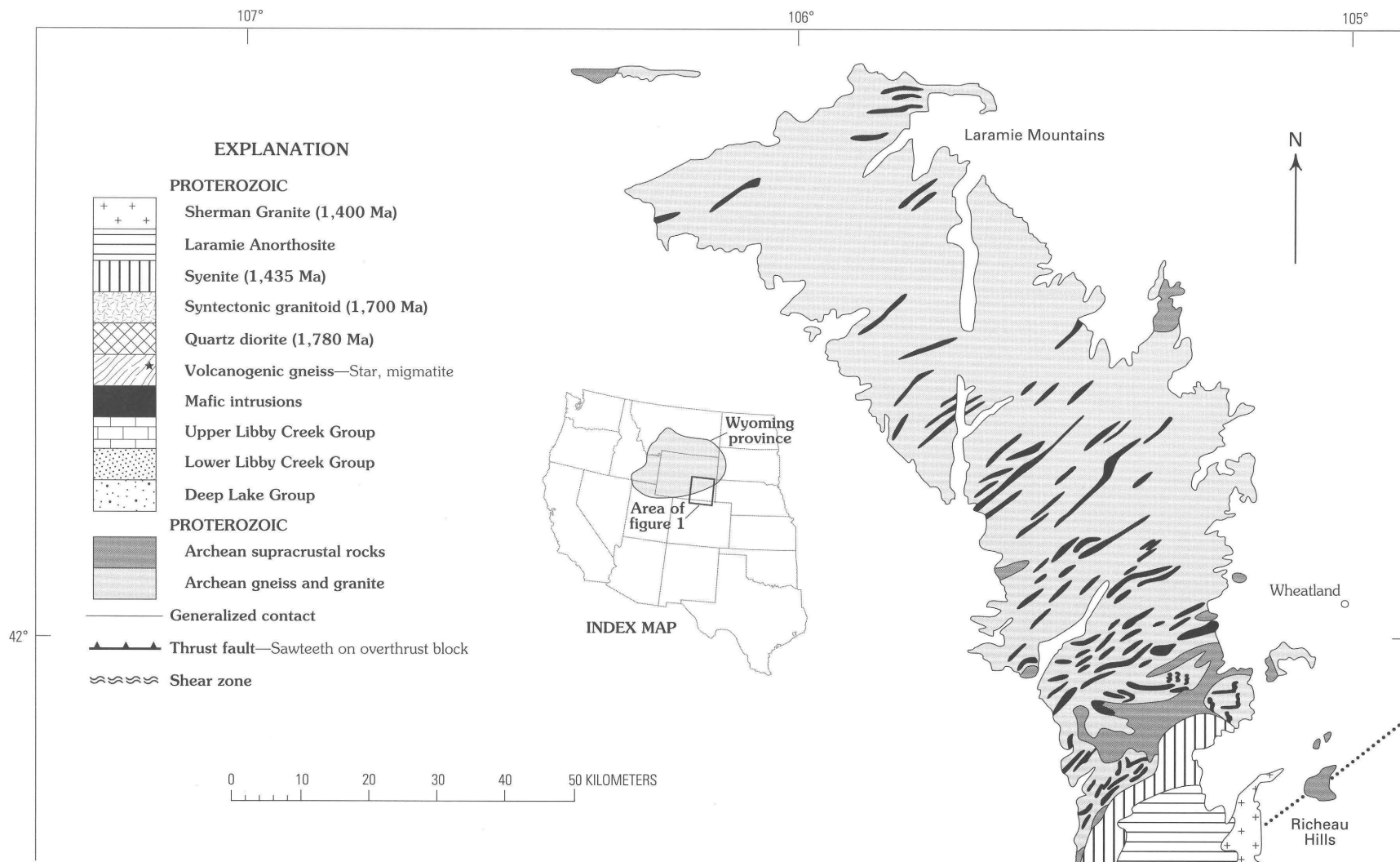
The Granite Village area has been developed for summer residents who enjoy the rural setting and cool weather during the summer and fall. As a result, the area is divided into numerous individual holdings. For a variety of reasons, trespass permission could not be obtained in many of these areas, although most individuals were more than hospitable. These access problems resulted in a mapping patchwork in which some areas were mapped in detail and others were extrapolated, were mapped by remote sensing techniques, or were taken from the earlier work of Blackwelder and of Harrison. Time constraints did not allow us to map the southwest corner of the area, and it was generalized from the work of Blackwelder and Harrison. For these reasons, we consider the product of our Granite Village area work as a reconnaissance map despite the fact that some areas were mapped in detail.

GENERAL GEOLOGY

The present study was undertaken to compare the metavolcanic rocks of this area with similar rocks in the southern Medicine Bow Mountains and Sierra Madre, which are Precambrian uplifts west of the Laramie Mountains (fig. 1). The Medicine Bow Mountains and Sierra Madre are divided into northern and southern domains by a major fault

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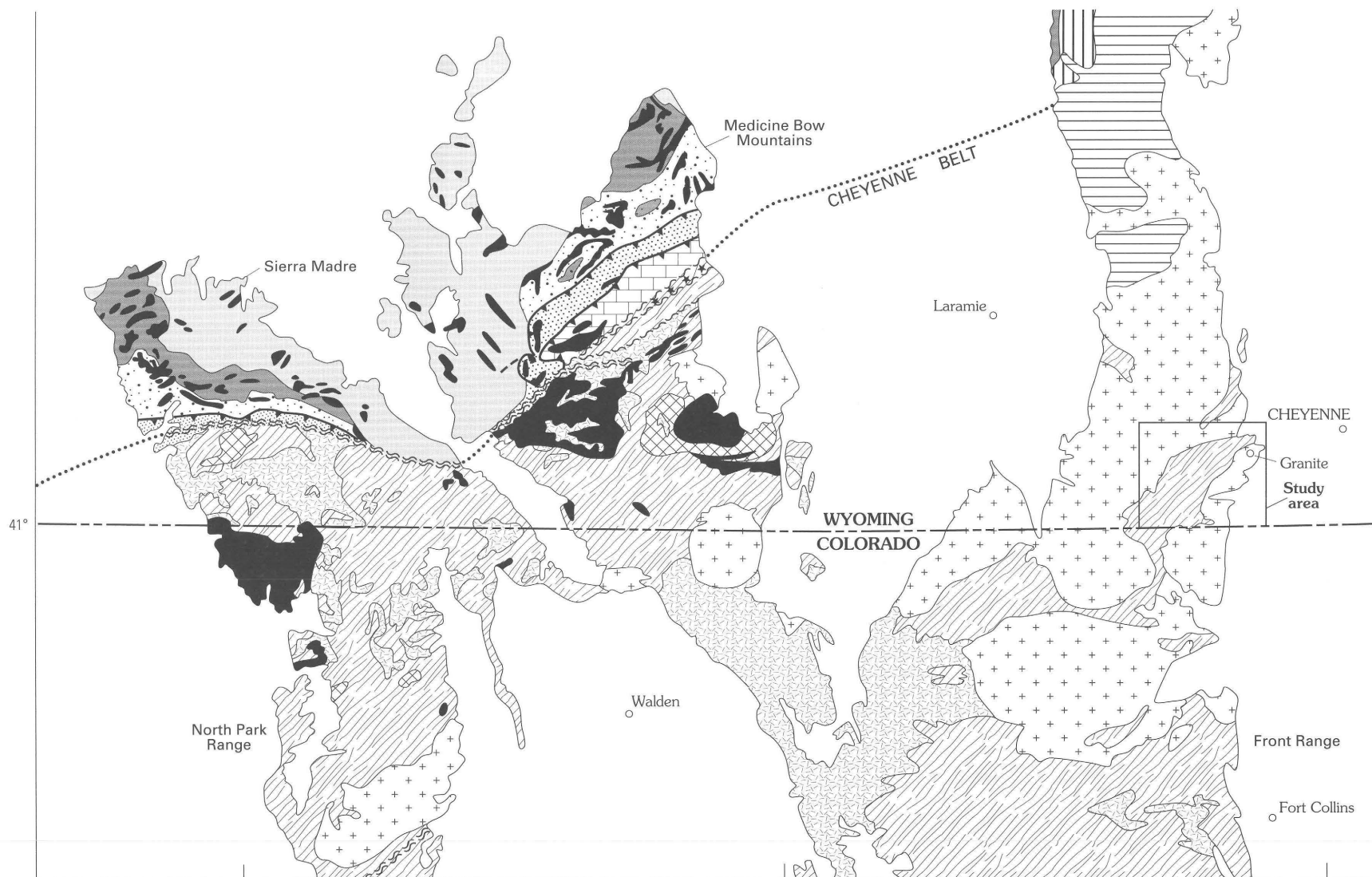


Figure 1. General geology and location of study area, southeastern Wyoming.

system, the Cheyenne belt (Houston and others, 1979). This fault system marks the boundary of the Wyoming Archean province; north of the fault, Early Proterozoic (2.4–1.9 Ga) metasedimentary rocks typical of a passive margin lie on Archean basement, whereas south of the fault, Early Proterozoic metavolcanic and metasedimentary rocks and comagmatic intrusive rocks (1.8 Ga) are exposed. The southern suite of rocks is considered juvenile crust (fig. 1; Houston, 1993). The Cheyenne belt has been interpreted as a suture where Early Proterozoic island arcs collided with an Early Proterozoic passive margin (Hills and Houston, 1979; Karlstrom and Houston, 1984; Houston, 1993).

The metavolcanic and metasedimentary rocks south of the Cheyenne belt have been referred to as the Green Mountain magmatic arc (Reed and others, 1987). The Green Mountain magmatic arc extends over an area some 65 km wide and is probably a series of island arcs combined to make a composite arc complex.

Metavolcanic rocks and comagmatic intrusions nearest the Cheyenne belt have been dated at ≈ 1.8 Ga (Premo and Van Schmus, 1989). The nearest reliable date of volcanic successions south of the Cheyenne belt is the Salida-Gunnison magmatic arc of Reed and others (1987), some 325 km south of the Cheyenne belt. These metavolcanic rocks range in age from 1.7 to 1.5 Ga. If the Cheyenne belt is projected into the Laramie Mountains (fig. 1), the metavolcanic rocks of the Granite Village area lie approximately 65 km south of the proposed suture. Thus it is possible that the Granite Village area is a separate volcanic arc with a different chemistry or age than the metavolcanics of the Sierra Madre and Medicine Bow Mountains. However, the information we have obtained to 1995 suggests that the volcanic rocks of the Granite Village area do not differ significantly from those of the Medicine Bow Mountains and Sierra Madre. The age of rocks of the Granite Village area has not been determined.

GEOLOGY OF THE GRANITE VILLAGE AREA

Metavolcanic and metasedimentary rocks are present as an enclave partly surrounded by and intruded by the 1.4 Ga Sherman Granite (fig. 1; pl. 1). Granite and granodiorite intrusives that are older than the Sherman Granite also invade the metavolcanic-metasedimentary succession. These intrusions are, in turn, cut by conformable intrusions, dikes, and sills of gabbro and diabase. Basalt and diabase dikes intrude the Sherman Granite, but some of these dikes are dismembered and partially engulfed by the Sherman Granite and thus exhibit the Sederholm³ effect (Sederholm, 1923).

³Sederholm (1923) noted that some basalt dikes intruded the same granite that intruded the basalt, suggesting either nearly synchronous emplacement or remobilization of the granite.

The degree of deformation and rank of metamorphism in the metavolcanic and metasedimentary rocks increase from north to south. Textures and structures in the metavolcanic-metasedimentary succession are best preserved in the vicinity of the village of Granite, Wyoming; in fact, some of the best exposures are in road cuts along U.S. Interstate Highway 80 near Granite (pl. 1). We have established a line striking roughly east-west, located approximately along the junction of T. 12 N. and T. 13 N., that marks the boundary between metavolcanic rocks with recognizable textures and structures (to the north) and gneisses and schists of indeterminate origin (to the south) (pl. 1).

Taking the study area as a whole, metavolcanic rocks are most abundant north of Duck Creek, although water-laid tuffs and silicic metavolcanic rocks that may be graywacke are common in an area along Lone Tree Creek (secs. 13 and 14, T. 13 N., R. 70 W.). South of Duck Creek, graywacke, pelitic schist, hornblende gneiss, and biotite gneiss interfinger with amphibolite and felsic gneiss. We believe that these rocks are a mixed volcanic-sedimentary succession containing a greater proportion of metasedimentary rocks, although intense deformation and metamorphism in this area make identification of protoliths uncertain.

Metavolcanic rocks in the northern part of the map area compose a bimodal suite that consists of rhyolite, rhyodacite, dacite, and basalt. These rocks are interpreted as a proximal suite, being in part subaerial because of the abundance of tuffaceous rocks, including agglomerate and possible welded tuff; pillow structures are sparse. They have geochemical affinities with arc volcanics of the southern Medicine Bow Mountains and Sierra Madre (Condie and Shadel, 1984) (table 1).

The principal structure in the northern part of the map area is an east-west-trending, steeply plunging syncline that is overturned in the east. In addition, Harrison (1951) identified a broad, steeply plunging, east-west synform outlined by a change in strike of foliation in granite of the southwestern part of this area. These east-west structures are the oldest ones that we have identified in the map area.

A major shear zone in the center of the map area is developed in the metavolcanic-metasedimentary succession and in older granite. The shear zone strikes east-west and is older than gabbroic intrusions and the Sherman Granite. We interpret the shear zone as a south-side-up structure developed during the same deformation that produced the east-west syncline and synform. A prominent north-northwest-striking antiform in the southern part of the map area, in the vicinity of Twin Mountains, is interpreted as a late fold, probably the deformed limb of an older east-west fold.

All rock types, including the Sherman Granite, are disrupted by north-northwest-striking faults. The faults are thought to have developed over a period of time during and after emplacement of Sherman Granite. Many of these faults have controlled the emplacement of mafic and felsic dikes. At least one major northwest fault is probably Laramide in age, as it displaces Phanerozoic sedimentary units east of the mapped area.

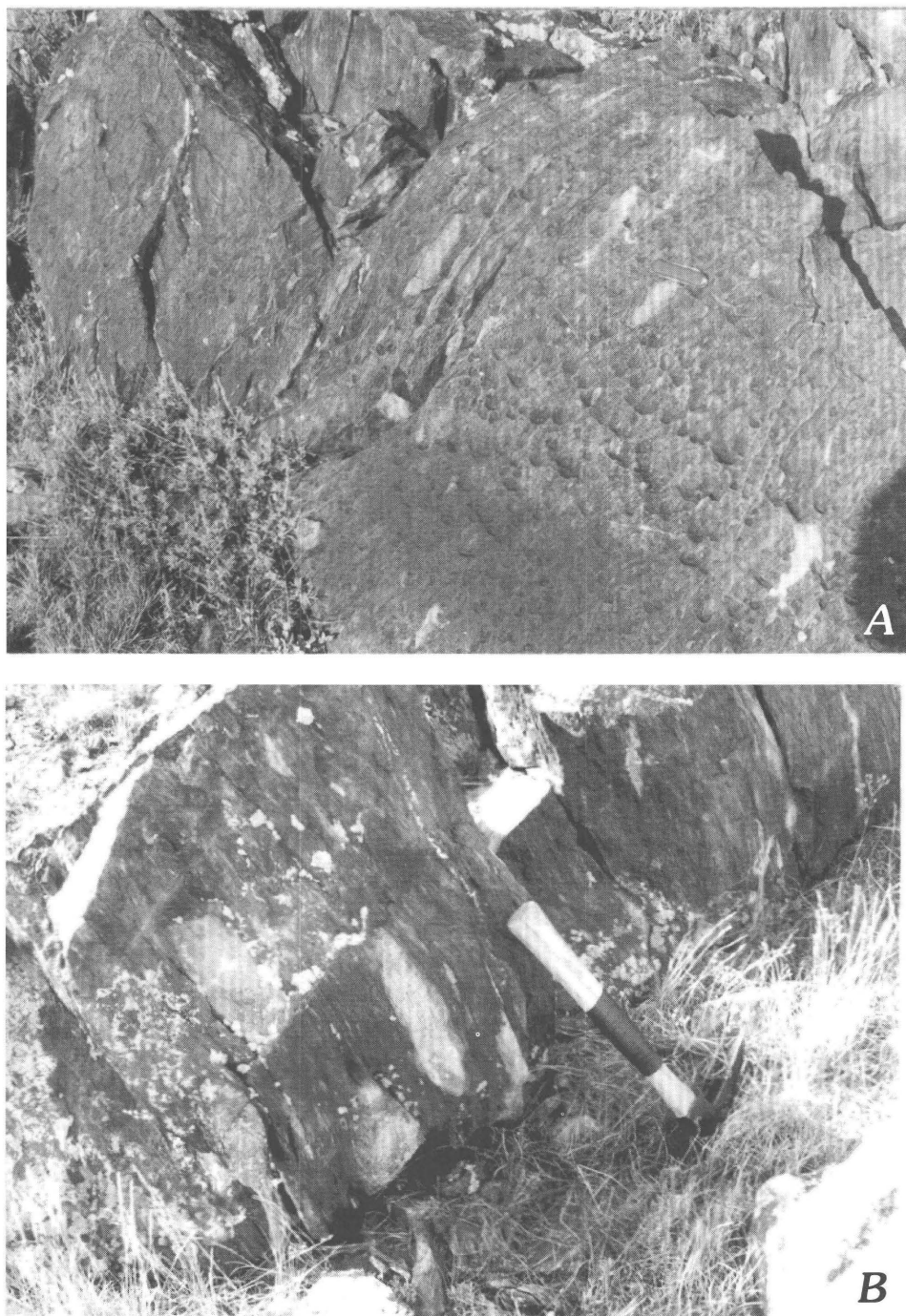


Figure 2. Metabasaltic tuff with fragments of felsic volcanics. *A*, Lapilli tuff, sec. 25, T. 13 N., R. 71 W. Knife for scale in upper right. *B*, Agglomerate, sec. 25, T. 13 N., R. 71 W. Hammer for scale.

DESCRIPTION OF METAVOLCANIC AND METASEDIMENTARY ROCKS

METABASALT

Metabasalt is interbedded with felsic volcanic rocks throughout the area. It is most abundant in the central part, north and south of Duck Creek (pl. 1). Inasmuch as metabasalt is less resistant to erosion than the felsic volcanic rocks, it is probably more abundant than suggested by the map relations. It is present as dense black layers that are probably

flows, but the most abundant metabasaltic rocks are tuffs that range from breccias with fragments 15 cm in diameter to fine-grained tuffs in which the fragments are barely recognizable in hand specimens (fig. 2). Pillows are rare in the volcanic succession. The best preserved pillow structures can be seen in a road cut on U.S. Interstate Highway 80 just west of the Remount Ranch exit. The metabasalt has been metamorphosed to amphibolite; it is composed of hornblende and andesine with minor quartz, opaque minerals, sphene, biotite, and epidote. Clinopyroxene is partly altered to amphibole in some specimens.

The chemical composition of metabasalt and metabasalt tuffs of this area is not significantly different from that of similar rocks of the Sierra Madre and Medicine Bow Mountains (table 1). The two samples from the Laramie Mountains (table 1, LM-6, -8) are slightly more siliceous than basalts of the Medicine Bow Mountains and Sierra Madre but are within the range of silica content exhibited in the Medicine Bow Mountains and Sierra Madre (table 1). The TiO_2 content in basalts in all three areas is low, suggesting an island-arc protolith (Condie and Shadel, 1984; Ware, 1982; Schmidt, 1983).

META-ANDESITE AND METABASALTIC ANDESITE

Meta-andesite and metabasaltic andesite are rare in the metavolcanic succession of the Laramie Mountains and are uncommon in the volcanic successions in the Medicine Bow Mountains or the Sierra Madre (table 1). The only rock of andesitic composition found in the Laramie Mountains area is a porphyritic meta-andesite (LM-12). Other metatuffs and flows that were thought to be andesitic, based on color and specific gravity, proved to be dacitic in composition based on chemistry. The Laramie Mountains metavolcanic succession is bimodal and resembles the volcanic rocks from the Medicine Bow Mountains and Sierra Madre, which are also bimodal (Divis, 1976; Schmidt, 1983; Condie and Shadel, 1984).

FELSIC METAVOLCANIC ROCKS

Felsic metavolcanic rocks that range in chemical composition from dacite to rhyolite are the most abundant volcanic rocks in the Granite Village area. In the area north of Duck Creek, where textures are better preserved, the felsic metavolcanic rocks range from breccia and agglomerate to lapilli tuff to tuff. These fragmental rocks are probably the most abundant, but quartz-feldspar porphyries and dense, very fine grained rocks are also common. Some of the porphyritic and fine-grained rocks are believed to be flows or ash-flow tuffs because they have a layered structure that resembles the eutaxitic structure seen in welded tuffs; however, glass shards were not identified in thin sections. Other porphyritic and fine-grained rocks are dikes and sills; they are especially common in the Saddleback syncline in the central part of the area (pl. 1; fig. 3).

Felsic metavolcanic rocks range in color from white to pink, to light gray, to dark gray, to black. Rock compositions could not be reliably distinguished in the field because some dark-colored felsic volcanics can be mistaken for mafic metavolcanic rocks were it not for their lower specific gravity.

Condie and Shadel (1984) have suggested that the relatively low MgO , CaO , TiO_2 , Ni , and Co of rhyolite of the Sierra Madre suggests that it is similar to calc-alkaline rhyolite. Metarhyolites and metarhyodacites of both the Granite Village area and the Medicine Bow Mountains are similar to those in the Sierra Madre (table 1). The only exception is a high MgO content of a metarhyodacite (sample LM-8) in the Granite Village area (table 1).

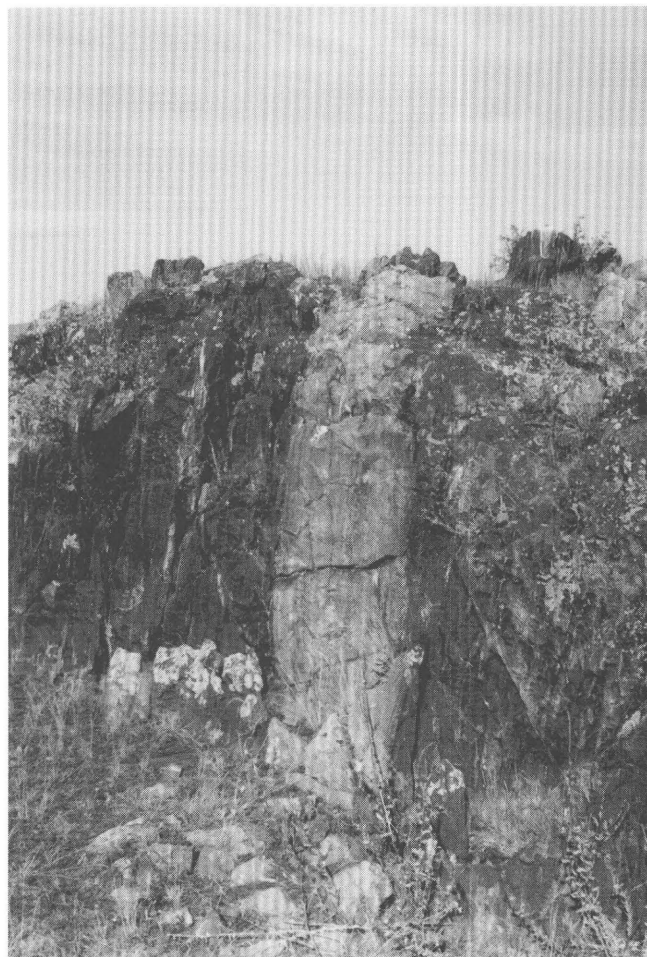


Figure 3. Rhyolite dike cutting metabasalt tuff, sec. 25, T. 13 N., R. 71 W. Dike 30 cm thick.

The chemical composition of rocks classed as meta-dacite is quite variable in the Granite Village area (table 1). Inasmuch as only three samples were analyzed from the Granite Village area, and only one in the Medicine Bow Mountains (table 1), compositional comparisons with the Sierra Madre are not meaningful.

METASEDIMENTARY ROCKS

Metasedimentary rocks that exhibit bedding, including graded bedding, are interlayered with the metavolcanic rocks in the area north of Duck Creek. These metasedimentary rocks are especially common along Lone Tree Creek, west-southwest of Willadsen school (school is in sec. 18, T. 13 N., R. 69 W.; pl. 1). Silica-rich metasedimentary rocks are uncommon in this general area but are abundant in NW $\frac{1}{4}$ sec. 24, NE $\frac{1}{4}$ sec. 23, T. 13 N., R. 70 W. Blackwelder (Darton and others, 1910) reported calc-schists and marble in local areas, including some exposures in prospect pits on the McLaughlin Ranch (SW $\frac{1}{4}$ sec. 28, T. 13 N., R. 70 W.). We interpret at least some of the gneisses and schists in the southern part of the map area as metasedimentary rocks.

GNEISSES AND SCHISTS INTERPRETED AS A MIXED VOLCANO-SEDIMENTARY SUCCESSION

Hornblende gneiss, biotite gneiss, amphibolite, and a variety of felsic gneisses and schists (Xmgn) that crop out south of Duck Creek are interpreted as an interlayered succession of metavolcanic and metasedimentary rocks. Where these rocks are considered to have a definite sedimentary protolith, the symbol Xms is used.

Hornblende gneiss, which is included in the Xmgn unit, is most abundant west and south of Twin Mountains where it is interlayered with biotite gneiss, amphibolite, and felsic gneiss. It is laterally equivalent to lower grade mafic metavolcanic rocks along strike to the west of Twin Mountains, suggesting that it is, perhaps in substantial part, of volcanic origin. The hornblende gneiss contains blue-green hornblende and plagioclase with accessory epidote and sphene; biotite, apatite, and opaque minerals are local in occurrence. Although we do not have chemical analyses of hornblende gneiss from the Laramie Mountains, it has a mineral content similar to hornblende gneiss in the southern Medicine Bow Mountains (table 2, Nos. SR-2, SR-3, SRD-4-34, SRD-4-19, SRD-4-24, and SRD-4-59). The Medicine Bow samples range in composition from basalt to dacite (table 2).

Felsic gneisses of the Twin Mountain area range from well-foliated pink and gray gneisses of variable but generally medium grained to fine-grained size to more massive granitoid rocks that are similar to the older granites of this area. In the area west of Twin Mountains, felsic gneisses resemble the felsic volcanics in the field in texture and color so strongly that they are mapped as part of the felsic volcanic suite (Xfv) (pl. 1). These rocks are primarily interlayered gray gneisses and fine-grained and medium-grained pink gneisses. This felsic suite is intruded by pink gneisses that resemble rhyolite dikes of the Saddleback syncline area (pl. 1). The pink gneisses consist of quartz, potassium feldspar, and minor amounts of biotite; muscovite, magnetite, and epidote may be present. The gray gneiss is composed of quartz, plagioclase, potassium feldspar, and biotite; epidote, magnetite, sphene, apatite, and garnet are accessory minerals. One sample of medium-grained pink gneiss was analyzed (table 6, No. LR-14); this pink gneiss is a sill within the gray gneiss succession. It is a high-calcium rock that does not correlate with the generally low calcium rhyolite of the Saddleback area.

Pink to gray granite gneisses (Xggn) that underlie the Twin Mountains area range from well-foliated gray gneiss containing local biotite-rich zones to poorly foliated pink gneisses that resemble the older granite of this area. The biotite-rich zones in the gray gneiss are layered and may exhibit isoclinal folds. The biotite-rich layers may be partially assimilated inclusions in a meta-igneous rock. The chemical composition of the gray gneiss (table 2, Nos. LR-2-27 and SR-4-10) shows that it is a high silica-low calcium rock that is chemically similar to rhyolite of the Saddleback area (table 1).

The three chemical analyses of felsic gneiss from the southern part of the area are not useful in determining the origin of these rocks. In fact, the pink gneiss sill that in the field resembles rhyolite has a chemical composition similar to a sedimentary rock, whereas the gray gneiss has a composition similar to the rhyolites of the Saddleback area.

METAMORPHISM

The volcanic rocks of this area are not as useful as pelites in defining metamorphic grade. Mineralogically and texturally, the rhyolites range from rocks that retain unaltered phenocrysts of potassium feldspar, plagioclase, and quartz in a fine-grained laminated, but recrystallized groundmass of quartz, feldspar, and biotite to rocks that are largely recrystallized. Dacites and rhyodacites typically appear recrystallized and contain biotite, chlorite, and blue-green amphibole, together with plagioclase, potassium feldspar, and quartz. Some dacites and rhyodacites have porphyroblasts of colorless garnet. Basalts are altered to amphibolite and consist of blue-green amphibole, plagioclase, and quartz with abundant opaque minerals and minor sphene as accessory minerals.

All metamorphic rocks are classed as amphibolite grade; the rank of metamorphism is higher in the south, because chlorite is absent in samples collected in the Twin Mountains area. Original textures and structures are obliterated in the rocks in the southern area, and these rocks are certainly more thoroughly recrystallized than rocks north of Duck Creek (pl. 1).

IGNEOUS ROCKS

Granodiorite, older granite, gabbro, diabase, and basalt intrude the metavolcanic-metasedimentary succession and are, in turn, intruded by various facies of the 1.4 Ga Sherman Granite. Mafic igneous rocks may, in part, be comagmatic with the volcanic successions. Comagmatic mafic igneous rocks are present in small podlike bodies and sills within the volcanic successions. The majority of mapped mafic intrusions crosscut the older granite. The Sherman Granite is intruded by basalt and diabase dikes that are, in turn, intruded by the Sherman Granite, showing the classic Sederholm effect (Sederholm, 1923). As noted, some of these mafic dikes are so disrupted by the Sherman Granite that they occur as pods of basalt and diabase enclosed by it (pl. 1). In other areas, the Sherman Granite contains inclusions of older basalt numerous enough to constitute mappable units consisting of approximately 50 percent mafic inclusions (pl. 1).

The Sherman Granite is intruded by felsic dikes that range from aplite to fine-grained porphyritic granite (pl. 1). These dikes are in north- to northeast-trending swarms and

cut all facies of the Sherman Granite. Harrison (1951) noted that the aplite dikes are typical crosscutting dikes with fine-grained borders, but that in some areas on Boulder Ridge (T. 12 N., R. 73 W.) the Sherman Granite corrodes and sends stringers completely across the dikes. We have noted the same relationship in both felsic and mafic dikes in Union Pacific railroad cuts west of Harrison Village.

GRANODIORITE

Granodiorite is present in the northern part of the map area and in outcrops along Lone Tree Creek (pl. 1). Inclusions of granodiorite occur in the Sherman Granite on Saddleback ridge and in other areas where they are, for the most part, too small to map. The granodiorite is intruded by both older granite and the Sherman Granite and with the possible exception of some mafic bodies is the oldest of the igneous intrusions.

The granodiorite is gray to dark gray and has medium-grained to porphyritic facies. In one area (sec. 9, T. 12 N., R. 70 W.), the medium-grained granodiorite is intruded by a porphyritic facies. The samples examined in thin section were plagioclase-rich rocks containing both quartz and potassium feldspar. Plagioclase constitutes approximately 60 percent of the rock with quartz and potassium feldspar making up approximately 10 percent each. The remaining 20 percent of the rock is chiefly amphibole, biotite, and epidote; sphene, apatite, and zircon are present as accessory minerals. Only one sample of the granodiorite was analyzed (table 3, sample LR-4-2), but the unit probably is variable in composition as shown by analyses of similar rock units from the Medicine Bow Mountains and Sierra Madre (table 3).

A similar but more strongly foliated and altered granodiorite has been described by Klein (1974) in the Silver Crown area, approximately 2.5 km north of this area. This granodiorite must correlate with that of this area, but it exhibits metamorphic textures and amphibolite-grade metamorphism (Klein, 1974, p.13), neither of which is typical of the granodiorite of this area.

MAFIC IGNEOUS ROCKS

All mafic igneous rocks in the area are metamorphosed to amphibolite. Gabbroic and diabasic textures can be recognized in the field, and partially altered clinopyroxene has been identified in some gabbro and diabase. As noted, these mafic rocks range in age from rocks equivalent in age to the metavolcanic rocks to mafic dikes that intrude the Sherman Granite. We have not been able to determine the relative age of most of these mafic rocks, so they are shown as one unit on the geologic map.

OLDER GRANITE

In initial studies of the southern Medicine Bow Mountains (Houston and others, 1968), we used the term "older granite" to describe granitoid rocks that were older than the Sherman Granite (which was dated as 1,400 Ma (Hills and others, 1968)) but which were undated. Subsequent geochronological study (Hills and Houston, 1979) indicated that the ages of these granitoid rocks range from approximately 1,730 Ma to 1,760 Ma. We have used the same term on the geologic map for undated granite older than the Sherman of this area. The informal term granite of Duck Creek has been used by Marlatt (1989) to describe older granite that crops out in the central part of the map area. The granite of Duck Creek crops out throughout much of the area of the geologic map and makes up a large part of the area mapped by Blackwelder (Darton and others, 1910) in the southwestern part of the map area (pl. 1).

The granite of Duck Creek intrudes the metavolcanic and metasedimentary succession and the granodiorite, and in turn is intruded by the Sherman Granite and some mafic and felsic dikes and intrusions (pl. 1). The granite of Duck Creek is a pink, medium- to coarse-grained granite that is difficult to distinguish from similar facies of the Sherman Granite. However, the granite of Duck Creek is generally well foliated (fig. 4) in contrast to the Sherman Granite, which is nonfoliated or which may have a very poorly developed foliation.

Foliation of the granite of Duck Creek is similar in attitude to that of the metavolcanic-metasedimentary succession in the southern part of the map area. At places the granite shows gradational contacts with the metavolcanic-metasedimentary succession. In the Twin Mountains area (sec. 31, 32, T. 13 N., R. 70 W.; secs. 5, 6, 7, 8, T. 12 N., R. 70 W.), a felsic gneiss and the granite of Duck Creek grade into each other, and some layers mapped as felsic gneiss may indeed be finer grained facies of the granite of Duck Creek.

Geologic field relationships to country rock (metavolcanic and metasedimentary rocks) and the Sherman Granite are the same for the granite of Duck Creek and the various older granites of the Medicine Bow Mountains and Sierra Madre. The Medicine Bow Mountains and Sierra Madre older granites range in age from approximately 1.73 Ga to 1.76 Ga (Houston, 1993). Except for larger intrusions such as the Sierra Madre Granite, which is only distinctly foliated near contacts with country rock, they are generally foliated. These granitoids are generally more calcic and contain slightly (about 0.5 percent) less potassium than the Sherman Granite but show a range in composition so that some, such as the Sierra Madre Granite, are chemically similar to the Sherman (tables 4 and 5). As might be expected from the chemistry, the ≈ 1.75 Ga granitoids contain a more calcic plagioclase than the Sherman and have less potassium feldspar. Otherwise, they are very similar in mineralogy. Typically, these granitoids contain equal amounts of plagioclase ($An_{30\pm}$) and potassium feldspar that together make up about 60 percent of



Figure 4. Granite of Duck Creek showing strong foliation and lineation, sec. 15, T. 13 N., R. 70 W. Knife placed parallel to foliation.

the rock. Quartz makes up 30 percent, and biotite, muscovite, amphibole, epidote, opaque minerals, sphene, garnet, zircon, apatite, and allanite in order of abundance make up the remainder.

The granite of Duck Creek is similar in chemistry and mineralogy to the older granitoids of the Medicine Bow Mountains and Sierra Madre and is considered a syntectonic intrusion or a late syntectonic intrusion emplaced some 30 Ma after arc-continent collision (Houston, 1993).

The granite of Duck Creek is peraluminous, as is true of most of the 1.75 Ga granite of the southern Medicine Bow Mountains and the Sierra Madre (table 4). The range in $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in the older granite (≈ 1.75 Ga) is wide, from 0.700 in the Big Creek Granite of the Medicine Bow Mountains (Hills and Houston, 1979) to 0.7088 in White Quartz Monzonite of the Sierra Madre (Divis, 1976). $^{87}\text{Sr}/^{86}\text{Sr}$ values for the granite of Duck Creek are lacking. This range in Sr isotope values may indicate that these granites are derived from different sources, but we believe that the majority are derived by crustal melting, based on their peraluminous nature and the fact that the crust is thickened where these granites occur. This crust was thickened beneath a Proterozoic island arc (Johnson and others, 1984). Some of these granites, such as the Rambler Granite of the Medicine Bow Mountains, which is strongly peraluminous (table 4) and has anomalous tin, are almost certainly derived from crustal melts.

SHERMAN GRANITE

The Sherman Granite composes a major Precambrian batholith that underlies an area extending westward from the eastern Laramie Mountains to the east-central Medicine

Bow Mountains, north as far as the central Laramie Mountains, and south to 16–17 km south of the Wyoming-Colorado border, into the Colorado Front Range (fig. 1). Well data and geophysical surveys suggest that the batholith extends beneath Phanerozoic cover between the Medicine Bow Mountains and the Laramie Mountains (fig. 1), a total area estimated to exceed 2,600 km².

Despite its impressive dimensions, the Sherman Granite has not been studied in the same detail that has been true of much of the Precambrian of southern Wyoming. The granitic outcrops of the Sherman were first noted by Hayden (1871), and the Wyoming portion of the batholith was mapped and designated the Sherman Granite by Blackwelder (Darton and others, 1910) some 40 years later. The Wyoming portion of the batholith has received the most attention, probably because of its association with the Laramie anorthosite complex. In the Laramie Mountains, the Sherman has been mapped by Fowler (1930), Harrison (1951), Newhouse and Hagner (1957), Smith (1977), Marlatt (1989), and Edwards (1993). The Medicine Bow Mountains portion of the batholith was mapped by Houston and others (1968) and the Colorado portion by Eggler (1968). The geochemistry of the batholith has been reviewed by Frost and others (1993) as part of their detailed study of the Laramie anorthosite complex.

Students of the Sherman Granite have recognized a number of different facies ranging from a very coarse grained almost pegmatitic facies (fig. 5) (considered by most workers as the dominant rock type) to pyroxene-bearing monzonites and ferrodiorite. There is, however, no general agreement on the number or relative age of these different rock types. All workers agree that the Sherman Granite and related dikes are the last igneous intrusions of Precambrian age in southern Wyoming, and the batholith

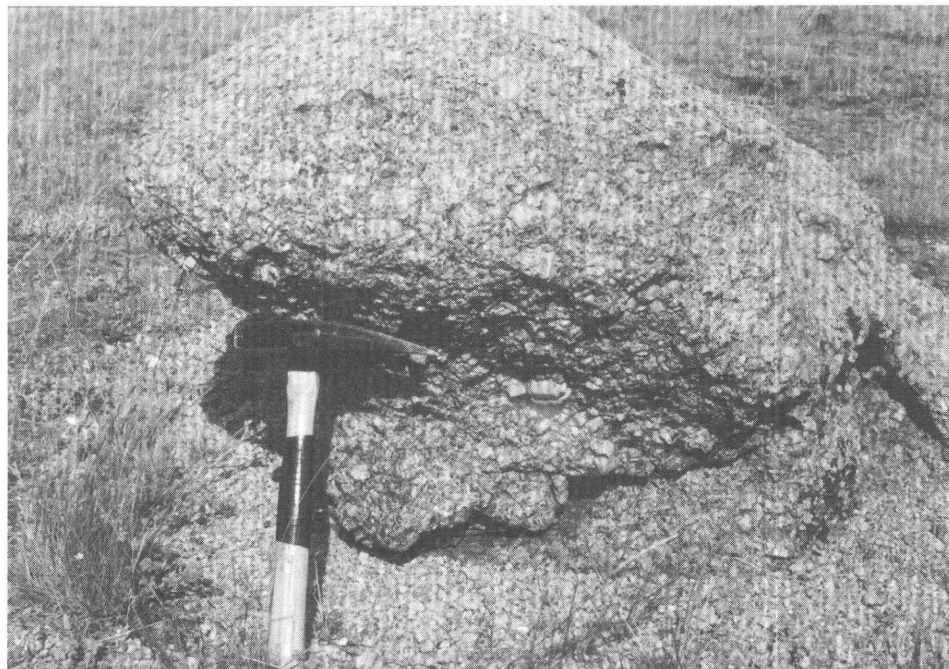


Figure 5. Coarse-grained Sherman Granite, sec. 19, T. 13 N., R. 71 W.

has been viewed as a classic post-tectonic intrusion or anorogenic batholith, as reviewed by Anderson (1983). The post-tectonic nature of the batholith was confirmed by geochronologists who have established an age of approximately 1.4 Ga for the Sherman, which is 400 Ma younger than the metavolcanic-metasedimentary succession and at least 340 Ma younger than the main deformational episode (Aleinikoff, 1983; Geist and others, 1990).

In the map area, rocks mapped as Sherman Granite include a fine-grained facies, a medium-grained facies, a porphyritic facies, and a coarse-grained facies. These rocks are mapped as Sherman because they intrude all other rock units except younger dikes and are generally nonfoliated. The fine- to medium-grained to porphyritic facies occur along the margin of the coarse-grained facies, which is the major rock type of this area. We believe that the finer grained to porphyritic facies is a border phase of the Sherman and is approximately the same age as the coarse-grained (typical) Sherman. Age relationships are uncertain, however, because in some areas the coarse-grained facies occurs as inclusions in the medium-grained Sherman, and in other areas the coarse-grained facies intrudes the fine-grained facies. This same conflicting relationship has been noted in the northern part of the Sherman outcrop area (Smith, 1977). Perhaps more than one set of intrusions exists with similar mineralogy and texture, but we prefer to consider the fine-grained to porphyritic Sherman as border facies, as was suggested earlier by Houston (1968) for the Sherman Granite of the Medicine Bow Mountains.

The medium-grained to porphyritic facies (Ysgm) of the Sherman of this report corresponds to the granite porphyry of Blackwelder (Darton and others, 1910) and is probably equivalent to the Lincoln Granite as mapped by Edwards

(1993) in the Pole Mountain area of the southwest Laramie Mountains. Blackwelder (Darton and others, 1910, p. 4) considered this granite porphyry a separate intrusion older than the Sherman Granite, but Edwards (1993) considered his Lincoln Granite as a facies of the Sherman that exhibited sharp contact with the coarse-grained "typical" Sherman. The medium-grained to porphyritic rocks are pink to pinkish gray and are generally darker in color than the coarse-grained Sherman. They consist of potassium feldspar, quartz, plagioclase, and perthite in varying proportions (plagioclase and quartz typically are more abundant than potassium feldspar); biotite and amphibole are principal accessory minerals. Muscovite, epidote, sphene, opaque minerals, apatite, zircon, and fluorite are also present as accessory minerals, but in minor amounts compared with biotite and amphibole. The percentage of accessory minerals (biotite and amphibole) varies from approximately 2 percent to as much as 10 percent.

The fine-grained Sherman Granite of this report occurs within the area mapped as medium grained to porphyritic (unit Ysgm on pl. 1) and is most common in the quarry at Granite village and in areas south of Granite village along I-80 (pl. 1). It does not differ significantly in mineralogy from the medium-grained facies and has gradational contacts with this facies.

Coarse-grained Sherman Granite (unit Ysg) is the most abundant rock type. It occurs throughout the area; some of the most spectacular outcrops of this facies are in broad barren flats along Lone Tree Creek and its tributary (secs. 17 and 18, T. 13 N., R. 70 W.). Coarse-grained Sherman is pink to red. It is less resistant to weathering than other facies and forms a gravelly grus that covers large areas of the southern Laramie Mountains. It ranges in texture from a

very coarse grained equigranular rock to a porphyritic granite containing large crystals of potassium feldspar (fig. 5). Some facies are pegmatitic.

The petrography of the Sherman Granite has been studied in most detail by Harrison (1951), McCallum (1964), Eggler (1968), and Edwards (1993). Potassium feldspar, in part perthitic, is the most abundant mineral in the granite, making up approximately 40 percent of the rock and exceeding 50 percent in some samples. Crystals of potassium feldspar may have plagioclase rims so that some specimens exhibit rapakivi texture. Quartz and plagioclase are next in abundance, averaging about 25 percent of the rock each, although quartz is usually more abundant than plagioclase. Plagioclase ranges between An12 and An30 and is zoned; both normal and reverse zonings have been reported (Harrison, 1951; Eggler, 1968). Myrmekite is present at contacts of plagioclase and microcline.

The coarse-grained Sherman Granite has a variety of accessory minerals, including blue-green amphibole, biotite, opaque minerals, epidote, apatite, allanite, sphene, chlorite, zircon, rutile, and fluorite. Amphiboles and biotite are the most abundant accessory minerals; they range from approximately 3 to 6 percent of the rock.

The Sherman Granite of this area, as well as samples from the Medicine Bow Mountains, is peraluminous (table 5). Frost and others (1993) noted that the Sherman bridges the boundary between peraluminous and meta-aluminous with the more mafic rocks falling in the meta-aluminous field. Frost and others (1993) also noted that the Sherman is predominantly subalkalic; the more mafic facies lie in the alkalic field. They reported that the REE characteristics of the Sherman, including light-REE-enrichment and a moderate negative Eu anomaly, are typical of Proterozoic anorogenic granites.

Aside from the characteristics of a granite formed by crustal melting, we cannot speculate on the origin of the Sherman from study of this area. The fact that the Sherman exhibits conflicting age relationships with both mafic and felsic dikes, contains large areas with inclusions of mafic rock, has disrupted and intruded dikes that extend for some distance along strike, and has some mafic dikes that are clearly crosscutting with no evidence of intrusion by the Sherman suggests an extended period of mafic and felsic magmatism during the emplacement of the Sherman. This apparently occurred without the introduction of significant intermediate magma. These field characteristics suggest that there was a source for both felsic and mafic magma during Sherman emplacement, and that some mafic magma was introduced prior to complete consolidation of the Sherman and some after the magma solidified.

DIKES

Felsic and mafic dikes were not examined in detail because we were unable to find unaltered examples. Mafic dikes examined in thin section are amphibolite; textures

suggest basalt and diabase protoliths. Eggler (1968) reported hornblende quartz monzonite, porphyrite alaskite, and alaskite dikes that he believed were related to the Sherman. Houston and others (1968) noted porphyritic quartz latite dikes that clearly cut the Sherman of the Medicine Bow Mountains.

Klein (1974) mapped aplitic quartz monzonite dikes in the Silver Crown area (2.5 km north of map area) that are younger than the Sherman Granite. These dikes contain approximately 60 percent feldspar (potassium feldspar slightly greater than plagioclase [An6–An15]) and 30 percent quartz. These aplitic quartz monzonite dikes probably correlate with the felsic dikes of this area.

PEGMATITE

Pegmatite is uncommon in the northern part of the area. Small pegmatite bodies are present in the granite of Duck Creek near the Sherman Granite contact in secs. 19 and 20, T. 13 N., R. 70 W. Small pegmatites like these of the northern part of the area are present in the Silver Crown area, where Klein (1974, p. 8) reported them to be abundant and to intrude all rock types. These pegmatites appear to be related to the Sherman Granite.

In the southern part of the area, in the general vicinity of Twin Mountains, pegmatite and pegmatized rocks are abundant. Two types of pegmatite exist, a strongly foliated pegmatite that occurs in the metasedimentary-metavolcanic succession, which is unzoned and is composed of quartz, potassium feldspar, biotite and muscovite, and a more massive faintly foliated pegmatite of similar composition that is associated with the granite of Duck Creek. The faintly foliated pegmatite occurs in large masses with diffused borders that exceed 30 m in length and 15 m in width. These larger bodies of pegmatite are resistant and are most abundant on the two promontories that constitute Twin Mountains.

King and Parker (1966) suggested that the foliation in the pegmatite developed after the masses were emplaced as undeformed intrusions.

STRUCTURE

The most prominent structure in the Granite Village area is an east-west syncline, the Saddleback syncline in the central part of the area north of Duck Creek. The syncline is defined by topping criteria (graded beds) and is overturned to the north on its east side (pl. 1). Mafic volcanic rocks are more common at the exposed base of the syncline and felsic rocks are more abundant in the core. Inasmuch as felsic and mafic volcanic rocks are interlayered throughout the area, we are not certain that the fact that the mafic volcanics are at the base of the syncline establishes a regional stratigraphy for the volcanic rocks.

We believe that we can recognize both primary layering and a secondary metamorphic foliation in the metasedimentary and metavolcanic rocks of the syncline. These two structure types are shown on plate 1 as a bedding symbol, if it is thought to be primary, and as a foliation symbol, if it is interpreted as metamorphic or if origin is uncertain. In general, the two structures are subparallel, but near the center of the syncline an east-west metamorphic foliation intersects bedding or flow structure at high angles (pl. 1).

The best defined lineation is stretched clasts in mafic volcanics (indicated by letter P or lineation arrow). Lineations resulting from rodding (R) and crenulations (C) have also been noted, but are uncommon. The plunge of lineation developed by elongation of clasts is steep, ranging from 65° to 85°. We have also noted lineation of uncertain origin (no letter on pl. 1) which plunges less steeply at 45°. We suspect that there is a lineation defined by intersection of primary and metamorphic foliation, but this structure has not been noted in the field.

The Saddleback syncline may be a more complicated structure than indicated by the topping evidence noted in this study, but our evidence suggests that it is a steeply plunging nearly isoclinal fold.

Harrison (1951) recognized an east-west-trending synform defined by foliation in the granite of Duck Creek in the southwestern part of the area (pl. 1). Inasmuch as foliation in the granite of Duck Creek conforms to that of the metavolcanic and metasedimentary rocks, this structure may have developed at the same time as the Saddleback syncline.

An east-west-trending shear zone, present in the center of the area south of the Saddleback syncline (pl. 1), is characterized by intensely mylonitized metavolcanic rocks best exposed in secs. 29 and 32, T. 13 N., R. 70 W. A mylonite is also developed in the granite of Duck Creek, although the width of mylonite zones is less in the granitic rocks. The shear zone must have developed during deformation that involved both the metavolcanic-metasedimentary succession and the granite of Duck Creek. The shear zone is intruded by metagabbro that has locally developed an east-west mylonitic foliation; both are cut by the Sherman Granite, which is unaffected by the deformation (pl. 1). Foliation in the mylonite dips steeply both north and south (80° to vertical). We have not been able to define a sense of shear in the mylonite zone either in the field or in thin section. If it is similar to shear zones in the Medicine Bow Mountains (Duebendorfer, 1986) we suspect it is south side up.

We initially interpreted the shear zone as a south-side-up fault that exposed a deeper level of the crust on the south. This interpretation was based on the fact that metamorphic grade is higher to the south, and pegmatites, possibly of metasomatic origin, are common in the south and absent north of the fault (Houston, 1993). However, continued mapping in the area of Duck Creek indicates that the change in metamorphic grade and loss of primary structure in the metasedimentary-metavolcanic suite occur irregularly and do not coincide with the shear zone (pl. 1). The metamorphic

change is in close proximity to the shear zone, so the interpretation may be correct, but additional geobarometric studies are required to solve the problem.

A north-northwest-striking antiform, the Twin Mountains antiform, is present in the south-central map area. Our reconnaissance study of foliation and lineation in this structure provides evidence of refolding. Most of the rocks in the Twin Mountains antiform are deformed so that primary structures are absent. Foliation is probably derived from an earlier bedding or flow structure, as suggested by King and Parker (1966), who studied an area near Twin Mountains Lake in some detail. King and Parker (1966) stated that the layering or foliation was transposed and cited as evidence the presence of foliated pegmatite that they believed was originally nonfoliated.

The foliation in the Twin Mountains antiform does conform to contacts between major map units, suggesting a general concordance with earlier structure despite the transposition and recrystallization. If the interpretation of King and Parker (1966) is correct, the Twin Mountains antiform is a fold developed by deformation of an earlier transposed foliation, suggesting the development of three S-surfaces.

Our study of the antiform confirms the concept suggested by King and Parker (1966), although we suspect that some original bedding may be preserved in minor folds and believe that a general concordance exists between the earlier bedding or layering and the foliation developed by transposition and recrystallization.

Minor folds have been noted, especially on the east limb of the antiform. These folds deform compositional layering given by alternating layers of dark minerals (biotite and amphibole) and quartzofeldspathic layers. Some of this compositional layering may be primary, although evidence such as crossbedding or graded bedding was not noted in the area. The majority of minor fold axes on the east limb of the antiform plunge south (50°–80°); some are asymmetric S folds. Several minor folds that plunge to the south-southeast, parallel to the axes of the antiform, are defined by compositional layering (pl. 1). In sec. 7, T. 12 N., R. 10 W., some of the foliation in metamorphic rocks that are believed to be metasedimentary locally has a low dip that steepens toward the southeast and northwest. This suggests folded foliation, an interpretation which is supported by shallow-plunging recumbent folds noted in the compositional layering of the shallow-dipping layers. The recumbent folds might have developed prior to the development of Z folds in the main foliation.

In both the southern Sierra Madre (Houston and Graff, 1995) and southern Medicine Bow Mountains (Houston and others, 1968), early recumbent folds have been noted that developed prior to the main deformation. Houston and Graff (1995) have suggested that the recumbent folds developed in a rock succession older than portions of the volcanic successions (Green Mountain Formation volcanic rocks of the Sierra Madre), but this interpretation has not been verified by geochronology.

Minor folds are apparently absent in rocks of the west limb of the antiform. Lineation on the west limb is given by orientation of amphiboles or by biotite streaks in the plane of foliation. Some lineations can be attributed to intersection of two S-surfaces, which we interpret as compositional layering and axial plane cleavage (pl. 1). All of these lineations trend parallel to the axes of the antiform and plunge south-southeast.

We do not have enough structural observations on the Twin Mountains antiform to be statistically accurate, but we believe that field evidence is sufficient to indicate that it is a late fold probably superimposed on the limb of an earlier east-west structure. A secondary, possibly tertiary, S-surface was developed parallel to the antiform axes during this episode.

North of Lone Tree Creek, foliation in the metamorphic rocks and granite of Duck Creek strikes northeast. We have not mapped far enough north to determine the significance of this change in strike. However, in the southern part of the Silver Crown area (2.5 km north of the map area), a northeast-trending foliation is present both in granodiorite and in metamorphic rock inclusions within the granodiorite (Klein, 1974). This foliation may be a continuation of the northeast structure noted in the map area north of Lone Tree Creek. Foliation in the granodiorite in the northern two-thirds of the Silver Crown area strikes north. Klein (1974) credited this change in strike to control by an east-west fault system.

Numerous northwest- to north-northwest-trending faults displace all units in the Granite Village area, including the Sherman Granite. Many of these fault traces are occupied by felsic and mafic dikes. The majority of these faults must have developed after emplacement, and, in part, during a late stage of crystallization of the Sherman Granite. They are probably about the same age as the Sherman (≈ 1.4 Ga).

The most prominent northwest-trending fault is the Spottewood fault, which crops out in the southeast corner of the map area (sec. 18, T. 12 N., R. 69 W.) and can be traced along a N. 50° W. strike for a distance of more than 16 km (pl. 1). This fault is Laramide in age because it offsets the Phanerozoic section east of the Precambrian outcrop area. It is left-lateral and may be a reactivated fault of Precambrian age.

MINERALIZED AREAS

A silicified zone (Xsi) with minor pyrite was noted in rhyolite in SE $\frac{1}{4}$ sec. 19 and SW $\frac{1}{4}$ sec. 20, T. 13 N., R. 70 W. This siliceous zone may be a stratiform layer of siliceous exhalite or chert. In SW $\frac{1}{4}$ sec. 13, T. 13 N., R. 70 W., disseminated pyrite and chalcopyrite present in rhyolite near the contact with metasedimentary rocks may represent a small volcanogenic stratiform deposit. Very minor mineralized material, chiefly pyrite, was noted in prospect pits in other areas. These mineral occurrences may also have been volcanogenic in origin.

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Table 1. Chemical composition of Early Proterozoic metavolcanic rocks of southeastern Wyoming.

[Analysts, Ardith J. Bartel, K. Stewart, and J. Taggart, U.S. Geological Survey, X-ray spectroscopy; samples LM 2-6—2-26, Steve Boese, University of Wyoming, ICP, A-A; *, sample from Divis (1976); #, sample from Condie and Shadel (1984); LOI, loss on ignition; --, not found; blank, not analyzed]

MEDICINE BOW MOUNTAINS															
	Metarhyolite	Metarhyodacite		Metadacite	Metabasalt			Pillowed metabasalt					Metadiabase		
Sample No.--	SR-4-18	SR4-14		SR4-13	SR4-15	SR4-9		SR4-1	SR4-2	SR4-3	SR4-4	SR4-5		SR4-6	SR4-38
SiO ₂	75.0	68.4		57.4	51.2	48.2		51.7	51.3	48.5	49.5	50.3		51.6	50.2
Al ₂ O ₃	13.7	16.2		16.4	18.1	14.7		15.2	14.9	15.0	14.0	12.9		13.3	16.5
Fe ₂ O ₃	1.29	2.7		7.25	10.2	9.78		9.13	9.25	12.8	10.0	11.0		13.9	9.76
MgO	0.22	1.14		1.14	4.43	7.63		7.58	7.62	7.85	7.62	7.30		6.79	8.41
MnO	<0.02	<0.02		0.11	--	0.21		0.14	0.14	0.18	0.16	0.19		0.22	0.15
CaO	0.64	0.70		6.14	7.41	11.4		9.40	9.76	9.27	12.1	11.2		6.89	6.70
Na ₂ O	3.80	6.17		5.72	4.31	2.12		2.17	1.87	2.38	1.65	2.82		4.13	3.86
K ₂ O	4.53	2.66		1.41	1.09	3.36		0.78	0.89	0.12	0.07	0.32		0.15	0.50
TiO ₂	0.07	0.26		0.71	1.14	0.91		0.99	0.97	0.87	0.91	0.83		0.87	0.95
P ₂ O ₅	<0.05	0.08		0.22	0.46	0.59		0.08	0.12	0.06	0.10	0.07		0.07	0.12
CO ₂															
H ₂ O															
LOI	0.56	0.83		2.15	1.66	1.15		3.25	2.86	3.05	3.05	3.13		2.77	2.59

LARAMIE MOUNTAINS																	
	Metarhyodacite								Metarhyolite								
Sample No.--	LM-2	LM-6	LM-8	LM-9	LM-13	LM-18		LM-7	LM-14	LM-15	LM-16	LM-20	LM-21	LM-2-9	LM-2-10	LM-2-25	LM-2-26
SiO ₂	65.3	65.8	68.2	65.1	65.2	66.5		76.6	75.6	72.2	71.6	70.0	71.4	72.0	76.3	70.3	78.4
Al ₂ O ₃	16.4	15.7	14.2	16.6	14.5	15.9		11.7	12.5	13.3	13.0	14.6	13.9	13.7	12.7	14.5	11.2
Fe ₂ O ₃	6.37	6.13	5.42	6.27	6.93	5.49		2.14	2.32	4.78	4.94	4.54	3.85	3.33	1.29	2.53	1.91
MgO	1.78	2.50	3.08	1.58	1.18	1.04		0.38	0.26	0.43	1.04	0.91	0.90	0.69	0.14	0.41	0.88
MnO	0.13	0.25	0.36	0.30	0.17	0.08		0.10	0.04	<0.02	<0.02	0.10	0.11	0.08	<0.02	0.09	0.18
CaO	1.45	0.51	0.36	0.65	4.05	4.38		0.85	1.50	0.44	1.59	2.16	1.13	2.34	2.11	1.4	0.69
Na ₂ O	2.66	3.34	2.09	2.63	3.37	3.09		3.81	3.70	1.31	2.69	4.97	4.07	5.31	3.72	4.35	4.18
K ₂ O	3.54	2.74	3.50	4.21	2.42	2.56		2.00	2.63	3.72	1.89	1.74	2.78	1.41	3.31	4.64	1.68
TiO ₂	0.61	0.43	0.48	0.50	0.83	0.50		0.15	0.16	0.49	0.32	0.44	0.37	0.60	<0.10	0.20	<0.10
P ₂ O ₅	0.17	0.10	0.10	0.10	0.29	0.11		<0.05	<0.05	0.15	0.08	0.14	0.08	0.30	<0.20	<0.20	<0.20
CO ₂																	
H ₂ O																	
LOI	1.29	1.52	1.39	1.35	0.66	0.26		1.35	0.31	2.75	3.08	0.52	0.77	0.41	0.53	0.61	0.60

Table 1. Chemical composition of Early Proterozoic metavolcanic rocks of southeastern Wyoming—*Continued.*

Sample No.--	LARAMIE MOUNTAINS						SIERRA MADRE						
	Metadacite		Meta-andesite		Metabasalt		Metarhyodacite		Metarhyolite-Metarhyodacite				
	LM-10	LM-5	LM-11	LM-12	LM-3	LM-2-6	*GM-205	*GM-203	*GM-303	*GM-313	*GM-310	*GM-207	
SiO ₂	62.9	58.2	59.4	53.8	51.1	52.0	64.56	68.82	69.20	73.86	72.40	72.52	
Al ₂ O ₃	17.1	15.4	13.1	17.9	13.8	14.3	15.00	14.81	13.89	13.64	13.50	14.39	
Fe ₂ O ₃	4.95	10.7	10.7	9.32	14.1	9.96	7.15	4.21	6.40	2.64	4.18	2.55	
MgO	2.04	4.34	5.11	3.88	5.89	6.86	1.83	0.38	0.03	0.01	0.01	0.70	
MnO	0.12	0.28	0.27	0.15	0.36	0.02	0.10	0.06	0.02	0.02	0.05	0.06	
CaO	3.86	1.53	5.35	9.10	10.2	10.56	4.39	2.33	1.31	0.16	0.05	2.32	
Na ₂ O	2.50	2.51	1.33	2.80	1.14	1.62	3.02	3.93	5.05	3.52	4.18	3.09	
K ₂ O	3.66	2.34	2.41	1.08	0.71	1.05	1.64	3.66	3.19	4.97	4.94	2.73	
TiO ₂	0.70	1.20	1.0	0.84	1.35	0.80	0.84	0.50	0.49	0.24	0.27	0.19	
P ₂ O ₅	0.12	0.49	0.27	0.26	0.21	0.70	0.43	0.19	0.14	0.09	0.10	0.15	
CO ₂							0.12	0.06	0.18	0.14	0.14	0.70	
H ₂ O							1.02	0.95	0.25	0.65	0.40	0.55	
LOI	0.85	2.19	0.51	0.68	0.80	1.09							

Sample No.--	SIERRA MADRE									
	Metarhyolite-Metarhyodacite					Metadacite				
	#GM-27	#GM-67	#GM-32	#GM-36	#GM-75	#GM-37	#GM-44	#GM-63	#GM-72	#GM-76
SiO ₂	76.52	72.44	75.57	77.20	69.01	64.65	60.48	62.25	66.39	65.15
Al ₂ O ₃	12.51	14.29	12.44	10.86	15.26	17.20	16.19	15.63	15.59	15.69
Fe ₂ O ₃	1.46	2.64	2.42	2.42	3.94	4.92	7.11	6.25	5.14	3.94
MgO	0.53	0.60	0.63	1.06	1.09	1.36	2.98	1.66	1.35	2.58
MnO	0.03	0.08	0.07	0.06	0.07	0.13	0.25	0.12	0.13	0.14
CaO	1.41	1.69	1.22	1.30	1.04	2.01	4.17	2.07	2.58	2.17
Na ₂ O	3.93	4.44	4.37	2.49	3.65	4.91	2.96	4.15	4.12	4.41
K ₂ O	2.26	2.47	2.14	3.33	4.40	3.24	3.56	3.23	3.11	2.67
TiO ₂	0.21	0.29	0.34	0.25	0.38	0.65	0.73	0.68	0.46	0.61
P ₂ O ₅	0.01	0.03	0.04	0.06	0.06	0.13	0.25	0.25	0.18	0.22
CO ₂										
H ₂ O										
LOI	0.62	0.41	0.27	0.20	0.40	0.19	0.88	0.10	0.18	0.44

SIERRA MADRE

Sample No.--	Metabasalt–Metabasaltic Andesite										Metabasalt(?)	
	#GM-9	#GM-15	#GM-16	#GM-33	#GM-34	#GM-46	#GM-51	#GM-53	#GM-56	#GM-57	*GM-206	*GM-301
SiO ₂	51.88	48.69	54.41	53.18	50.85	50.98	50.72	50.79	47.60	50.24	50.50	53.02
Al ₂ O ₃	15.80	15.89	14.97	15.82	15.80	15.99	16.34	15.79	15.46	17.70	16.55	24.00
Fe ₂ O ₃	0.61	12.75	11.31	10.99	10.73	9.78	12.28	10.97	12.16	9.33	11.06	7.11
MgO	3.86	5.94	4.33	3.82	5.69	6.28	4.21	3.98	9.76	5.79	4.30	1.30
MnO	0.39	0.34	0.24	0.19	0.20	0.30	0.29	0.42	0.26	0.26	0.16	0.31
CaO	11.56	8.77	7.26	9.40	10.91	10.10	8.29	11.58	11.82	11.60	10.81	2.56
Na ₂ O	4.29	3.71	4.54	4.30	3.71	3.44	4.10	3.78	2.01	3.33	3.98	2.44
K ₂ O	0.13	0.35	0.52	0.83	0.60	0.86	1.30	0.09	0.18	0.66	0.30	8.08
TiO ₂	0.84	0.97	1.06	1.03	0.78	0.74	1.03	0.80	0.88	0.72	1.12	0.43
P ₂ O ₅	0.23	0.25	0.28	0.26	0.21	0.11	0.29	0.23	0.20	0.18	0.50	0.18
CO ₂											0.04	0.14
H ₂ O											0.35	0.64
LOI	1.16	2.11	1.30	0.42	0.41	1.36	0.97	1.11	0.10	0.33		

SAMPLE LOCALITIES

[lat N., long W.]

SR4-18.	Metarhyolite, lat 41°16'22", long 106°09'56".	LM-18.	Metarhyodacite, lat 41°05'59", long 105°13'15".	GM-205.	Amphibole schist, N. Fk. Encampment R.
SR4-14.	Metarhyodacite, lat 41°17'06", long 106°10'04".	LM-7.	Metarhyolite, welded tuff?, lat 41°05'27", long 105°12'44".	GM-203.	Felsic schist, N. Fk. Encampment R.
SR4-13.	Metadacite, lat 41°17'06", long 106°10'04".			GM-303.	Felsic schist, Fletcher Park.
SR4-15.	Metalapilli tuff (mafic fragments–gray ground-mass), lat 41°16'22", long 106°09'56".	LM-14.	Metarhyolite, welded tuff?, lat 41°05'53", long 105°12'32".	GM-313.	Felsic schist, Fletcher Park.
SR4-9.	Metalapilli tuff (mafic fragments–gray ground-mass), lat 41°17'31", long 106°10'14".	LM-15.	Metarhyolite breccia, lat 41°04'35", long 105°16'05".	GM-310.	Felsic schist, Fletcher Park.
SR4-1.	Towner Greenstone, lat 41°21'08", long 106°45'.	LM-16.	Metarhyolite breccia, lat 41°04'02", long 105°11'14".	GM-207.	Felsic schist, Green Mountains.
SR4-2.	Towner Greenstone, lat 41°21'18", long 106°15'29".	LM-20.	Metarhyolite tuff, lat 41°04'50", long 105°12'17".	GM-27.	Rhyolite, Sierra Madre.
SR4-3.	Towner Greenstone, lat 41°21'24", long 106°15'.	LM-21.	Metarhyolite tuff, lat 41°05'03", long 105°12'19".	GM-67.	Rhyolite, Sierra Madre.
SR4-4.	Towner Greenstone, lat 41°21'35", long 106°14'48".			GM-32.	Rhyolite, Sierra Madre.
SR4-5.	Towner Greenstone, lat 41°21'30", long 106°14'46".	LM-2-9.	Metarhyolite, lat 41°04'38", long 105°16'42".	GM-36.	Rhyolite, Sierra Madre.
SR4-6.	Diabase cutting Towner Greenstone, lat 41°21'00", long 106°59'.	LM-2-10.	Metarhyolite, lat 41°04'30", long 105°10'52".	GM-75.	Rhyodacite, Sierra Madre.
SR4-38.	Diabase cutting Towner Greenstone, lat 41°16'40", long 106°21'15".	LM-2-25.	Metarhyolite, lat 41°05'29", long 105°11'22".	GM-37.	Dacite, Sierra Madre.
LM-2.	Metarhyodacite, lat. 41°05'40", long 105°12'44".	LM-2-26.	Metarhyolite, lat 41°05'21", long 105°11'52".	GM-44.	Dacite, Sierra Madre.
LM-6.	Metarhyodacite (welded tuff?), lat 41°05'31", long 105°12'36".	LM-10.	Metadacite tuff, lat 41°05'58", long 105°12'40".	GM-63.	Dacite, Sierra Madre.
LM-8.	Metarhyodacite lapilli tuff, lat 41°05'29", long 105°12'45".	LM-5.	Metadacite tuff, lat 41°05'40", long 105°12'34".	GM-72.	Dacite, Sierra Madre.
LM-9.	Metarhyodacite, clots of garnet, lat 41°05'36", long 105°12'44".	LM-11.	Metadacite tuff, lat 41°05'56", long 105°12'38".	GM-76.	Dacite, Sierra Madre.
LM-13.	Metarhyodacite, lat 41°05'24", long 105°12'34".	LM-12.	Basaltic metaandesite, porphyritic, lat 41°05'53", long 105°12'36".	GM-9.	Basalt, Sierra Madre.
		LM-3.	Metabasalt tuff, lat 41°05'37", long 105°12'32".	GM-15.	Basalt, Sierra Madre.
		LM-2-6.	Metabasalt, lat 41°03'56", long 105°18'27".	GM-16.	Basaltic andesite, Sierra Madre.
		GM-206.	Hornblende schist, N. Fork Encampment River.	GM-33.	Basaltic andesite, Sierra Madre.
		GM-301.	Hornblende schist, Fletcher Park.	GM-34.	Basalt, Sierra Madre.
				GM-46.	Basalt, Sierra Madre.
				GM-51.	Basalt, Sierra Madre.
				GM-53.	Basalt, Sierra Madre.
				GM-56.	Basalt, Sierra Madre.
				GM-57.	Basalt, Sierra Madre.

Table 2. Chemical composition of Early Proterozoic hornblende gneiss, amphibolite, pelitic schist, calc-silicate gneiss, and graywacke of southeastern Wyoming.

[Samples LR-2-21, LR-2-27, SRD-21—SRD-Ma, SM-W-15—SM-W, analyst, Steve Boese, University of Wyoming, ICP, A-A; SR-4-10, analyst, A.J. Bartel, USGS, X-ray spec. SR-PS-11—SR-5, Japan Analytical Lab; SM-D-HG402—D-HG412, from Divis, 1976. --, not found; blank, not analyzed]

LARAMIE MOUNTAINS				MEDICINE BOW MOUNTAINS										
Sample No.--	LR-2-21	LR-2-27	SR-4-10		SR-PS-11	SR-2-22B	SR-1	SR-2	SR-3	SR-4	SR-5	SR-D-21	SR-3-1	SRD-4-53
SiO ₂	60.7	63.2	60.0		60.10	62.33	47.35	57.34	62.05	46.87	47.24	63.20	64.53	64.77
Al ₂ O ₃	15.6	16.3	18.0		15.60	14.64	16.44	16.73	16.73	15.84	13.52	15.14	16.63	15.90
Fe ₂ O ₃	8.01	7.0	7.26	Fe ₂ O ₃	1.93	2.58	4.50	2.87	2.05	2.98	4.89	6.78	7.80	7.99
				FeO	4.31	4.47	7.79	4.36	2.61	9.61	9.92			
MgO	2.25	4.37	1.98		2.79	3.04	5.49	3.82	1.73	6.48	5.40	2.26	2.45	2.41
MnO	0.18	0.13	0.10		0.06	0.09	0.20	0.13	0.08	0.21	0.23	0.06	0.10	0.11
CaO	4.50	0.91	2.72		7.97	6.81	10.79	7.18	4.12	10.52	9.58	0.45	0.35	0.62
Na ₂ O	3.28	2.47	3.47		3.56	2.51	3.16	3.93	5.30	3.08	3.63	1.83	0.55	1.69
K ₂ O	2.51	1.87	2.88		0.89	1.19	1.04	1.55	3.83	0.75	0.98	6.63	4.62	4.53
TiO ₂	1.4	0.8	0.48		1.08	0.67	0.91	0.43	0.56	1.14	2.31	0.87	0.76	0.68
P ₂ O ₅	0.4	<0.2	0.39		0.47	0.17				0.23	0.36	--	--	--
CO ₂					0.03	0.06	0.03	0.02	0.08	0.02	0.04			
H ₂ O					1.60	1.27	2.74	1.74	1.17	2.22	2.63			
LOI	0.56	1.40	2.38									1.79	0.63	1.62

MEDICINE BOW MOUNTAINS												SIERRA MADRE	
Sample No.--	SRD-4-34	SRD-4-9	SRD-4-24	SRD-4-59	SRD-4-26	SRD-4-27	SRD-4-11	SRD-4-18	SRD-21A	SRD-21B	SRD-21C	SRD-Ma	SM-W-15
SiO ₂	52.90	50.65	58.40	55.40	70.35	63.59	59.00	69.4	64.28	69.20	64.5	47.4	49.1
Al ₂ O ₃	12.88	11.96	13.31	17.02	13.92	14.86	16.88	14.5	16.58	13.66	15.6	17.0	13.2
Fe ₂ O ₃	17.37	11.17	12.36	8.65	5.67	8.06	7.23	4.36	6.49	5.46	6.89	11.95	13.9
MgO	4.90	9.97	2.03	3.30	1.48	2.07	3.10	1.14	1.88	1.83	1.59	7.30	7.15
MnO	0.28	0.21	0.29	0.15	0.06	0.07	0.08	0.04	0.08	0.05	0.08	0.16	0.23
CaO	8.38	8.23	6.92	5.37	1.24	2.07	5.28	3.97	4.11	1.14	1.50	11.36	10.09
Na ₂ O	1.31	1.62	2.19	3.06	6.00	3.39	3.60	2.05	3.59	2.76	2.42	2.85	3.21
K ₂ O	0.46	2.09	0.51	2.58	0.35	3.17	1.33	1.86	2.09	2.95	3.33	0.31	1.00
TiO ₂	1.83	0.75	1.56	1.57	0.67	0.89	0.72	0.53	0.70	0.58	0.65	0.8	1.3
P ₂ O ₅		0.24	0.74	0.59	--	--	--	--	--				
CO ₂													
N ₂ O													
LOI	0.67	1.84	0.36	1.68	1.16	0.87	2.10	1.71	0.95	1.54	2.11		

SIERRA MADRE												
Sample No.--	SM-W-B-15	SM-W-B-2	SM-W-62	SM-W-27B	SM-W-B-9	SM-WA	SM-WB	SM-WC	SM-WD	SM-D-HG402	SM-D-HG403	SM-D-HG412
SiO ₂	48.6	48.6	46.1	47.9	47.7	49.1	49.1	43.38	50.31	50.45	51.33	51.10
Al ₂ O ₃	15.5	21.0	12.9	13.9	13.6	15.75	18.40	20.23	16.62	16.67	12.75	14.84
Fe ₂ O ₃	12.2	5.95	16.79	15.99	16.04	11.38	9.67	14.27	11.41	9.07	15.57	13.09
MgO	6.38	5.10	2.94	7.19	7.33	0.64	0.66	0.86	0.96	5.95	5.01	5.28
MnO	0.25	0.096	1.10	0.25	0.19	0.17	0.12	0.05	0.16	0.15	0.09	0.20
CaO	8.44	12.94	16.89	10.57	9.80	20.05	18.16	16.80	16.91	11.74	8.40	10.35
Na ₂ O	3.79	3.20	1.91	2.34	2.38	1.07	1.90	1.73	2.22	3.35	2.05	2.47
K ₂ O	1.39	0.66	0.22	0.73	0.73	0.16	0.11	0.08	0.18	0.80	0.46	0.69
TiO ₂	1.0	0.4	1.1	1.6	1.3	0.74	0.85	0.78	0.61	0.62	2.39	0.86
P ₂ O ₅										0.41	1.30	0.51
CO ₂										0.08	0.16	0.10
H ₂ O										0.64	0.55	0.45
LOI												

SAMPLE LOCALITIES					
[lat N., long W.]					
LR-2-21.	Metagraywacke(?), lat 41°13'17", long 105°17'53".	SRD-4-59.	Hornblende gneiss, Barber Lake.	SM-W-B-2.	Medium-grained amphibolite, SE ¹ / ₄ sec. 24, T. 12 N., R. 83 W.
LR-2-27.	Metagraywacke(?), lat 41°15'22", long 105°12'16".	SRD-4-26.	Metagraywacke, Mullen Creek, sec. 20, T. 15 N., R. 79 W.	SM-W-62.	Medium-grained amphibolite, NW ¹ / ₄ sec. 32, T. 13 N., R. 83 W.
SR-4-10.	Metagraywacke(?), lat 41°17'25", long 106°10'.	SRD-4-27.	Metagraywacke, Mullen Creek, sec. 20, T. 15 N., R. 79 W.	SM-W-27B	Medium-grained amphibolite, SE ¹ / ₄ sec. 31, T. 13 N., R. 83 W.
RS-PS-11.	Paraamphibolite, sec. 9, T. 13 N., R. 81 W.	SRD-4-11.	Metagraywacke, Mullen Creek, sec. 20, T. 15 N., R. 79 W.	SM-W-B-9.	Medium-grained amphibolite, NW ¹ / ₄ sec. 34, T. 13 N., R. 83 W.
SR-2-22D.	Paramphibolite, Illinois Creek, sec. 26, T. 13 N., R. 79 W.	SRD-4-18.	Metagraywacke, Mullen Creek, sec. 20, T. 15 N., R. 79 W.	SM-WA.	Calc-silicate gneiss, sec. 11, T. 12 N., R. 83 W.
SR-1.	Amphibolite, Deerhorn Point.	SRD-21A.	Biotite-quartz schist, Mullen Creek, sec. 20, T. 15 N., R. 79 W.	SM-WB.	Calc-silicate gneiss, sec. 11, T. 12 N., R. 83 W.
SR-2.	Hornblende gneiss, Deerhorn Point.	SRD-21B.	Biotite-quartz schist, Mullen Creek, sec. 20, T. 15 N., R. 79 W.	SM-WC.	Calc-silicate gneiss, sec. 11, T. 12 N., R. 83 W.
SR-3.	Felsic hornblende gneiss, Deerhorn Point.	SRD-21C.	Biotite-quartz schist, Mullen Creek, sec. 20, T. 15 N., R. 79 W.	SM-WD.	Calc-silicate gneiss, sec. 11, T. 12 N., R. 83 W.
SR-4.	Amphibolite, SW ¹ / ₄ sec. 16, T. 12 N., R. 80 W.	SRD-Ma.	Metasedimentary rock (layered), Mullen Creek, sec. 20, T. 15 N., R. 79 W.	SM-D-HG402.	Hornblende-plagioclase gneiss, Big Creek.
SR-5.	Amphibolite, SW ¹ / ₄ sec. 16, T. 12 N., R. 80 W.	SM-W-15.	Medium-grained amphibolite, SW ¹ / ₄ sec. 1, T. 12 N., R. 84 W.	SM-D-HG403.	Hornblende-plagioclase gneiss, Big Creek.
SRD-21.	Pelitic schist, Barber Lake.	SM-W-B-15.	Medium-grained amphibolite, NE ¹ / ₄ sec. 14, T. 12 N., R. 83 W.	SM-D-HG412.	Hornblende-plagioclase gneiss, East Slope Blackhall Mtn.
SRD-3-1.	Pelitic schist, Barber Lake.	SM-W-81.	Medium-grained amphibolite, SW ¹ / ₄ sec. 14, T. 12 N., R. 84 W.		
SRD-4-53.	Pelitic schist, Barber Lake.				
SRD-4-34.	Hornblende gneiss, Barber Lake.				
SRD-4-19.	Hornblende gneiss, Barber Lake.				
SRD-4-24.	Hornblende gneiss, Barber Lake.				

Table 3. Chemical composition of Early Proterozoic quartz diorite and granodiorite of southeastern Wyoming.

[Sample LR-4-2, SR70-10, SR10-35, M399-M448, analysts, A.J. Bartel, K. Stewart, J. Taggart, USGS, X-ray spectroscopy; D-202—D-210 from Divis, 1976; C-54—C-79 from Condie and Shadel, 1984]

LARAMIE MOUNTAINS			MEDICINE BOW MOUNTAINS							SIERRA MADRE						
Granodiorite			Keystone Quartz Diorite							Encampment River Granodiorite						
Sample No.--	LR-4-2		SR 70-10	SR 10-35	M-399	M-407B	M-435	M-448		D-202	D-203	D-205	D-210	C-54	C-78	C-79
SiO ₂	65.3		67.1	59.8	63.6	60.7	62.1	60.3		69.98	67.20	66.64	61.16	71.75	63.97	72.44
Al ₂ O ₃	16.4		15.3	17.2	16.3	16.7	16.8	16.5		13.20	15.28	15.35	15.93	15.79	15.17	13.87
Fe ₂ O ₃	6.37	Fe ₂ O ₃ FeO	1.3	2.2	2.1	2.1	2.2	2.3		4.11	4.67	4.71	7.34	2.99	6.49	2.68
			2.8	4.6	3.2	4.1	3.4	4.0								
MgO	1.78		1.7	2.9	2.3	2.8	2.2	2.6		0.76	0.88	0.85	1.67	3.98	1.65	0.69
MnO	0.07		0.07	0.14	0.05	0.07	0.06	0.07		0.10	0.13	0.10	0.08	0.06	0.08	0.03
CaO	1.45		4.0	6.2	5.6	6.9	5.7	6.1		2.23	1.90	2.12	3.67	2.05	2.57	1.70
Na ₂ O	2.66		3.7	3.7	3.6	3.9	3.9	3.7		3.60	4.35	3.75	3.55	3.68	3.45	3.57
K ₂ O	3.54		2.0	1.5	1.7	1.2	1.5	1.4		4.00	4.01	4.09	5.06	3.59	5.29	3.53
TiO ₂	0.61		0.47	0.68	0.61	0.63	0.65	0.64		0.43	0.48	0.48	0.50	0.33	0.49	0.30
P ₂ O ₅	0.13		0.15	0.30	0.22	0.22	0.25	0.25		0.23	0.26	0.24	0.36	0.07	0.20	0.05
CO ₂			<0.05	<0.05	0.02	0.10	0.02	0.04		1.20	0.38	0.30	0.08			
H ₂ O			+0.6	0.63	0.95	0.91	0.80	0.93		0.87	0.95	0.55	0.22			
			-0.11	0.12	0.05	0.03	0.07	0.04								
LOI	1.29													0.19	0.22	0.53

SAMPLE LOCALITIES

LR-4-2.	Granodiorite, lat 41°21'18" N., long 106°45' W.	D-202.	Encampment River Granodiorite, Standard Park.
SR-70-10.	Keystone Quartz Diorite, S. Sheep Mtn., MBM.	D-203.	Encampment River Granodiorite, Standard Park.
SR-70-35.	Keystone Quartz Diorite, E. Lake Creek, MBM.	D-205.	Encampment River Granodiorite, N. Fork Encampment River.
M-399.	Keystone Quartz Diorite, Douglas Creek, MBM.	D-210.	Encampment River Granodiorite, near Willow Creek.
M-407B.	Keystone Quartz Diorite, Douglas Creek, MBM.	C-54.	Encampment River Granodiorite, typical sample.
M-435.	Keystone Quartz Diorite, Douglas Creek, MBM.	C-78.	Encampment River Granodiorite, typical sample.
M-448.	Keystone Quartz Diorite, Douglas Creek, MBM.	C-79.	Encampment River Granodiorite, typical sample.

Table 4. Chemical composition of older granite and quartz monzonite of southeastern Wyoming.

[Samples LM-2-2—LM-M, analyst, Steve Boese, University of Wyoming; SR-M-224—SR-M-520, analyst, Hezekiah Smith, USGS, Rapid Rock Method; SR-22—SR-37, analysts, A.J. Bartel, K. Stewart, J. Taggart, USGS, X-ray spectroscopy. KD-3-8, 3-10, MPD-4-28, HD-4-13, 4-14, CD-4-10—4-25, analyst, Steve Boese, University of Wyoming, ICP, A-A. D-21—D-211 from Divis, 1976]

LARAMIE MOUNTAINS								MEDICINE BOW MOUNTAINS							
Granite of Duck Creek								Keystone Quadrangle quartz monzonite							
Sample No.--LM-2-2	LM-2-7	LM-2-15	LM-2-17	LM-2-18	LM-2-20	LM-M		SR-M-330	SR-M-337	SR-M-464	SR-M-525	SR-M-526	SR-M-527	SR-M-536	SR-M-540
SiO ₂	72.6	68.7	71.4	73.2	73.7	69.9	77.0	72.9	71.8	74.9	73.3	73.8	73.0	72.5	73.7
Al ₂ O ₃	13.6	16.5	13.5	12.9	13.0	15.1	11.4	14.4	14.9	13.3	13.7	13.8	14.4	14.0	14.4
Fe ₂ O ₃	2.28	2.11	1.86	1.42	1.58	2.87	1.4	0.9	0.67	0.98	0.60	0.36	0.6	1.6	0.86
								FeO	1.2	1.20	0.56	1.0	0.76	1.0	0.76
MgO	0.42	0.37	0.51	0.36	0.28	0.77	0.03	0.2	0.41	0.43	0.35	0.33	0.33	0.60	0.32
MnO	0.05	0.07	0.04	0.04	0.03	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00
CaO	2.39	1.40	1.80	1.50	0.90	2.09	0.2	1.5	1.5	2.0	1.40	1.60	1.10	1.10	1.40
Na ₂ O	3.94	5.12	3.86	3.86	4.27	3.79	3.4	3.6	3.7	2.8	3.3	3.60	3.70	3.2	3.40
K ₂ O	3.83	5.14	4.04	4.14	4.41	4.78	4.9	4.6	4.1	4.7	4.7	4.7	4.0	3.8	4.6
TiO ₂	0.3	0.5	<0.1	<0.1	<0.1	0.2	0.1	0.22	0.21	0.08	0.15	0.09	0.10	0.30	0.17
P ₂ O ₅	0.5	0.6	<0.2	<0.2	<0.2	0.2	<0.02	0.04	0.15	0.05	0.04	0.05	0.09	0.10	0.05
CO ₂								0.04	0.04	0.03	0.08	0.03	0.02	0.01	0.03
H ₂ O								+0.6	0.89	0.75	0.74	0.77	0.85	1.4	0.98
								-0.05	0.05	0.08	0.05	0.05	0.06	0.15	0.02
LOI	0.74	0.48	0.55	0.38	0.37	0.76	0.7								

MEDICINE BOW MOUNTAINS													
Rambler Granite													
Sample No.--	SR-M-224	SR-M-225B	SR-M-306	SR-M-316B	SR-M-517	SR-M-518	SR-M-519	SR-M-520	SR-22	SR-24	SR-25	SR-31	SR-35
SiO ₂	75.1	74.9	75.0	75.5	74.3	75.6	72.4	76.2	73.4	75.8	76.3	71.5	72.4
Al ₂ O ₃	12.9	14.5	13.5	14.6	14.7	14.2	14.0	12.6	13.7	14.0	12.9	14.4	14.3
Fe ₂ O ₃	0.56	0.54	0.79	0.54	0.42	0.59	1.6	0.55	1.95	1.23	1.39	2.77	2.03
FeO	0.40	0.16	0.16	0.24	0.16	0.16	1.2	0.28					
MgO	0.20	0.19	0.11	0.15	0.08	0.04	0.29	0.07	0.23	<0.10	0.11	0.42	0.57
MnO	0.00	0.01	0.00	0.08	0.00	0.03	0.00	0.00	0.05	0.26	0.02	0.03	0.05
CaO	1.10	1.0	0.81	1.10	0.49	0.39	0.95	0.47	1.24	0.41	0.14	1.36	1.35
Na ₂ O	3.0	4.9	0.31	6.4	5.30	4.50	3.1	3.1	3.29	5.90	3.29	3.53	3.35
K ₂ O	5.2	3.6	5.2	1.6	2.7	3.10	5.2	5.0	4.69	1.03	3.68	4.73	4.18
TiO ₂	0.11	0.00	0.11	0.00	0.00	0.00	0.26	0.00	0.17	<0.02	<0.02	0.28	0.20
P ₂ O ₅	0.01	0.05	0.01	0.08	0.05	0.05	0.03	0.00	0.05	0.1	0.08	0.07	0.06
CO ₂	0.10	0.07	0.09	0.04	0.03	0.02	0.02	0.03					
H ₂ O	+0.84	0.62	0.67	0.40	0.54	0.54	0.64	0.53					
	-0.06	0.06	0.11	0.04	0.04	0.03	0.03	0.01					
LOI									0.71	0.41	0.38	0.81	1.29

MEDICINE BOW MOUNTAINS											SIERRA MADRE		
Mullen Creek Granite								Mullen Creek Granite			Boat Cr.	Sierra Madre Granite	
								(leuco-phase)			Granite		
Sample No.--	SR-32	SR-33	KD-3-8	KD-3-10	MPD-4-28	HD-4-13	HD-4-14	CD-4-10	CD-4-14	CD-4-25	SR-37	D-21	D-41
SiO ₂	74.0	73.9	73.99	72.95	74.35	74.64	73.59	75.99	75.20	75.23	71.8	73.85	73.00
Al ₂ O ₃	13.6	13.9	13.06	13.94	13.24	13.32	13.44	12.78	13.43	13.52	15.0	15.10	15.03
Fe ₂ O ₃	1.48	1.52	1.11	1.88	2.13	1.65	2.00	0.74	1.69	1.58	2.26	1.51	1.80
MgO	0.27	0.28	0.26	0.27	0.40	0.24	0.25	0.07	0.25	0.21	0.58	0.01	0.04
MnO	<0.02	<0.02	0.03	0.04	0.04	0.03	0.04	0.05	0.02	0.02	0.05	0.03	0.05
CaO	1.16	1.27	1.06	1.20	1.13	0.43	1.51	0.24	0.66	0.94	2.56	0.16	1.13
Na ₂ O	3.10	3.22	3.11	3.11	3.28	3.09	3.19	3.65	3.43	2.98	4.00	3.90	2.38
K ₂ O	4.59	4.52	4.67	5.12	4.15	5.02	4.12	5.57	4.55	4.33	2.22	4.67	5.62
TiO ₂	0.16	0.16	0.29	0.20	0.13	0.12	0.24	0.03	0.07	0.15	0.18	0.25	0.47
P ₂ O ₅	<0.05	<0.05	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.13
CO ₂												0.12	0.14
H ₂ O												0.38	0.25
LOI	0.81	0.69	0.40	0.76	1.27	1.06	0.90	0.51	0.69	0.95	0.89		
SIERRA MADRE													
Sierra Madre Granite								White Quartz Monzonite					
Sample No.--	D-45	D-48	D-52	D-54	D-105	D-143	D-211	D-152	D-043	D-104	D-105	D-106	D-110
SiO ₂	77.03	71.59	76.90	73.00	76.28	77.75	74.65	76.84	71.90	71.34	73.50	70.34	71.74
Al ₂ O ₃	12.29	14.70	13.40	13.33	12.51	11.75	13.65	13.17	14.75	15.35	14.63	14.30	15.41
Fe ₂ O ₃	2.27	2.73	1.26	3.32	2.44	1.93	1.68	1.96	1.99	2.42	1.00	4.40	1.46
MgO	0.02	0.13	0.02	0.02	0.01	0.04	0.01	0.02	0.25	0.39	0.02	0.36	0.22
MnO	0.02	0.06	0.01	0.15	0.01	0.03	0.05	0.01	0.02	0.02	0.01	0.03	0.02
CaO	0.34	1.15	0.35	1.31	0.29	0.28	0.33	0.01	1.42	1.25	0.66	1.43	1.13
Na ₂ O	1.59	2.81	3.10	3.50	3.60	3.06	3.63	2.10	3.52	3.24	3.30	2.82	3.60
K ₂ O	5.31	5.32	4.21	4.66	4.34	4.93	4.93	5.05	4.87	4.85	5.58	5.25	5.11
TiO ₂	0.43	0.47	0.12	0.43	0.14	0.08	0.14	0.08	0.35	0.34	0.06	0.30	0.19
P ₂ O ₅	0.08	0.13	0.03	0.12	0.10	0.09	0.10	0.09	0.10	0.12	0.09	0.15	0.18
CO ₂	0.18	0.24	0.20	0.18	0.21	0.14	0.24	0.20	0.16	0.12	0.14	0.14	0.14
H ₂ O	0.38	0.58	0.35	0.28</									

SAMPLE LOCALITIES

LM-2-2.	Older granite, lat 41°04'39" N., long 105°17'20" W.	SR-35.	Rambler Granite, lat 41°13'16" N., long 106°15'30" W.
LM-2-7.	Older granite, lat 41°03'51" N., long 105°17'14" W.	SR-32.	Mullen Creek Granite, lat 41°13'30" N., long 106°22'42" W.
LM-2-15.	Older granite, lat 41°02'59" N., long 105°17'00" W.	SR-33.	Mullen Creek Granite, lat 41°13'28" N., long 106°22'42" W.
LM-2-17.	Older granite, lat 41°03'10" N., long 105°16'08" W.	KD-3-8.	Mullen Creek Granite, Medicine Bow Mountains.
LM-2-18.	Older granite, lat 41°04'10" N., long 105°08'01" W.	KD-3-10.	Mullen Creek Granite, Medicine Bow Mountains.
LM-2-20.	Older granite, lat 41°03'15" N., long 105°17'51" W.	MPD-4-28.	Mullen Creek Granite, Medicine Bow Mountains.
LM-M.	Older granite, Remount Ranch.	HD-4-13.	Mullen Creek Granite, Medicine Bow Mountains..
SR-M-330.	Older granite, Keystone quadrangle, Medicine Bow Mountains.	HD-4-14.	Mullen Creek Granite, Medicine Bow Mountains.
SR-M-337.	Older granite, Keystone quadrangle, Medicine Bow Mountains.	CD-4-10.	Mullen Creek Granite, leuco-phase, Medicine Bow Mountains.
SR-M-464.	Older granite, Keystone quadrangle, Medicine Bow Mountains.	CD-4-14.	Mullen Creek Granite, leuco-phase, Medicine Bow Mountains.
SR-M-525.	Older granite, Keystone quadrangle, Medicine Bow Mountains.	CD-4-25.	Mullen Creek Granite, leuco-phase, Medicine Bow Mountains.
SR-M-526.	Older granite, Keystone quadrangle, Medicine Bow Mountains.	SR-37.	Boat Creek Granite, lat 41°10'32" N., long 106°18'26" W.
SR-M-527.	Older granite, Keystone quadrangle, Medicine Bow Mountains.	D-21.	Sierra Madre Granite (foliated quartz monzonite) Dead Horse Park.
SR-M-536.	Older granite, Keystone quadrangle, Medicine Bow Mountains.	D-41.	Sierra Madre Granite (red granite), S. of Willow Park, Sierra Madre.
SR-M-540.	Older granite, Keystone quadrangle, Medicine Bow Mountains.	D-45.	Sierra Madre Granite (red granite), S. of Willow Park, Sierra Madre.
SR-M-224.	Rambler Granite, Medicine Bow Mountains.	D-48.	Sierra Madre Granite (augen gneiss), spillway Hog Park Res., SM.
SR-M-225B.	Rambler Granite, Medicine Bow Mountains.	D-52.	Sierra Madre Granite (fol. quartz monzonite), Hog Park Creek, SM.
SR-M-306.	Rambler Granite, Medicine Bow Mountains.	D-54.	Sierra Madre Granite (quartz monzonite), Green Timber Creek, SM.
SR-M-316B.	Rambler Granite, Medicine Bow Mountains.	D-105.	Sierra Madre Granite (quartz monzonite), Continental Divide, SM.
SR-M-517.	Rambler Granite, Medicine Bow Mountains.	D-143.	Sierra Madre Granite (augen gneiss) Continental Divide, Sierra Madre.
SR-M-518.	Rambler Granite, Medicine Bow Mountains.	D-211.	Sierra Madre Granite (quartz monzonite) NW flank Green Mtn., SM.
SR-M-519.	Rambler Granite, Medicine Bow Mountains.	D-152.	Sierra Madre Granite (quartz monzonite) SE trang. Stu. Willow, SM.
SR-M-520.	Rambler Granite, Medicine Bow Mountains.	D-043.	White Quartz Monzonite, Hog Park Road, Sierra Madre.
SR-22.	Rambler Granite, lat 41°14' N., long 106°16'04" W.	D-104.	White Quartz Monzonite, W. of South Soldier Creek, Sierra Madre.
SR-24.	Rambler Granite, lat 41°13'56" N., long 106°15'54" W.	D-105.	White Quartz Monzonite, lower Beaver Creek.
SR-25.	Rambler Granite, lat 41°14'16" N., long 106°16' W.	D-106.	White Quartz Monzonite, lower Beaver Creek.
SR-31.	Rambler Granite, lat 41°13'08" N., long 106°15'30" W.	D-110.	White Quartz Monzonite, Hog Park.

Table 5. Chemical composition of Sherman Granite of southeastern Wyoming.

[Samples MR-4—MR-6, LR-2-3—LR-2-22, analyst, Steve Boese, University of Wyoming; SR-1-12—SR-1-15, U.S. Geological Survey, Rapid Rock Method; G-10—G-14 from Geist and others, 1987]

Sample No.--	LARAMIE MOUNTAINS									MEDICINE BOW MOUNTAINS			
	MR-4	MR-5	LR-2-22	LR-2-3	LR-2-19	MR-6	G-10	G-11	G-14	SR-1-12	SR-1-13	SR-1-14	SR-1-15
SiO ₂	71.1	74.1	73.2	76.9	74.1	74.6	70.81	69.56	72.33	69.7	70.6	70.5	72.6
Al ₂ O ₃	13.1	12.3	12.4	12.4	12.8	12.8	14.68	14.54	13.61	14.5	14.7	15.0	14.3
Fe ₂ O ₃	Fe ₂ O ₃	2.2	1.9	3.09	1.39	2.23	0.7	2.58	3.17	2.0	1.8	1.5	1.8
	FeO	1.6	0.3				0.7				1.7	1.6	1.3
MgO	0.18	0.12	0.08	0.13	0.08	0.31	0.50	0.35	0.39	0.59	0.46	0.46	0.26
MnO	--	--	0.03	0.02	0.04	--	0.05	0.04	0.03	0.08	0.03	0.03	0.03
CaO	1.1	0.4	0.25	0.51	0.62	0.7	1.44	1.54	0.74	1.6	1.8	1.5	1.7
Na ₂ O	3.7	3.3	3.41	4.23	3.0	4.5	3.47	3.70	3.27	3.6	3.5	3.4	3.8
K ₂ O	5.5	5.6	5.85	4.32	6.06	4.1	6.45	6.41	6.28	4.8	5.0	5.0	3.9
TiO ₂	0.4	0.3	0.1	<0.1	<0.1	0.1	0.29	0.30	0.23	0.34	0.36	0.37	0.34
P ₂ O ₅	0.6	0.0	0.2	0.4	1.0	--	0.08	0.04	0.03	0.11	0.13	0.13	0.11
CO ₂										0.02	0.02	0.02	0.02
H ₂ O										+1.0	1.1	0.84	0.8
										-0.10	0.05	0.12	0.08
LOI			0.42	0.48	0.42		0.55	0.33	0.69				

SAMPLE LOCALITIES

MR-4.	Fine-grained quartz porphyry, Granite Village Quarry.	G-11.	Typical Sherman Granite.
MR-5.	Fine-grained quartz porphyry, Granite Village Quarry.	G-14.	Typical Sherman Granite.
LR-2-22.	Sherman Granite, coarse grained, Saddleback Mountains.	SR-1-12.	Coarse-grained Sherman Granite, Sheep Mountain.
LR-2-3.	Medium-grained Sherman Granite, SE sec. 24, T. 13 N., R. 71 W.	SR-1-13.	Coarse-grained Sherman Granite, Sheep Mountain.
LR-2-19.	Fine-grained quartz porphyry, Saddleback Mountains.	SR-1-14.	Coarse-grained Sherman Granite, Sheep Mountain.
MR-6.	Coarse-grained Sherman Granite, SE sec. 24, T. 13 N., R. 71 W.	SR-1-15.	Coarse-grained Sherman Granite, Sheep Mountain
G-10.	Typical Sherman Granite.		

Table 6. Chemical composition of felsic gneiss of southeastern Wyoming.

[Samples LR-14, LR-16A, B, analyst, A.J. Bartel, USGS, X-ray spec.; SR-8-29-1, 2-11, 3-3, Japan Analytical Lab.; HG121, HGCo25, HGC116, HGC121, from Divis, 1976; SM-W-D-8, W-D-9, analyst, Steve Boese, University of Wyoming, ICP, A-A]

LARAMIE MOUNTAINS					MEDICINE BOW MOUNTAINS				SIERRA MADRE					
Sample No.--	LR-14	LR-16A	LR-16B		SR-8-29-1	SR-2-11	SR-3-3		HG121	HGCo25	HGC116	HGC121	SM-W-D-8	SM-W-D-9
SiO ₂	71.9	76.1	77.1		72.22	72.41	75.5		74.50	69.45	68.44	77.46	69.7	71.4
Al ₂ O ₃	13.0	11.5	11.4		14.54	13.74	11.75		14.01	16.60	15.76	12.90	13.2	11.2
Fe ₂ O ₃	3.29	1.63	1.39	Fe ₂ O ₃	0.85	1.40	2.22		1.22	2.37	3.76	1.63	4.39	4.62
				FeO	0.45	1.63	0.88							
MgO	0.49	<0.05	<0.05		0.46	0.61	0.17		0.13	0.50	0.88	0.03	1.22	0.95
MnO	0.11	0.02	0.02		0.02	0.03	0.01		0.03	0.03	0.05	0.02	0.09	0.07
CaO	5.71	0.70	0.72		1.31	2.60	0.63		1.11	1.14	4.59	0.06	3.54	1.06
Na ₂ O	3.12	3.94	3.79		3.68	4.16	3.42		3.10	2.65	4.08	2.65	3.61	2.43
K ₂ O	0.38	4.63	4.55		5.29	2.32	4.36		5.23	5.74	1.16	4.91	1.89	5.23
TiO ₂	1.00	<0.1	<0.1		0.10	0.23	0.21		0.12	0.45	0.38	0.08	0.5	0.3
P ₂ O ₅	0.7	<0.2	<0.2						0.13	0.21	0.22	0.07		
CO ₂					0.06	0.0	0.0		0.14	0.17	0.18	0.05		
H ₂ O					1.23	1.16	0.77		0.39	0.65	0.65	0.33		
LOI	0.32	0.40	0.32											

SAMPLE LOCALITIES

LR-14.	Pink felsic gneiss, west of Twin Mountain Lake.	HG121.	Feldspathic gneiss, north-northeast Commissary Park.
LR-16a.	Gray felsic gneiss, SE 1/4 sec. 31, T. 13 N., R. 70 W.	HGCo25.	Feldspathic gneiss, Damfino Creek.
LR-16b.	Gray felsic gneiss, SE 1/4 sec. 31, T. 12 N., R. 70 W.	HGC116.	Feldspathic gneiss, Gasteal Creek.
SR-8-29-1.	Quartzofeldspathic gneiss, Big Creek Ranch.	HGC121.	Feldspathic gneiss, W. Big Creek Park.
SR-2-11.	Quartzofeldspathic gneiss, Pelton Creek.	SM-W-D-8.	Quartzofeldspathic gneiss, NE 1/4 sec. 1, T. 12 N., R. 84 W.
SR-3-3.	Quartzofeldspathic gneiss, Six Mile Gap.	SM-W-D-9.	Quartzofeldspathic gneiss, SE 1/4 sec. 1, T. 12 N., R. 84 W.

Manuscript approved for publication June 11, 1996
 Published in the Central Region, Denver, Colorado
 Photocomposition and text illustrations by Carol A. Quesenberry
 Plate graphics by Dave Castor and Norma J. Maes
 Edited by Lorna Carter

