WYOMING STATE GEOLOGICAL SURVEY
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Laramie, Wyoming

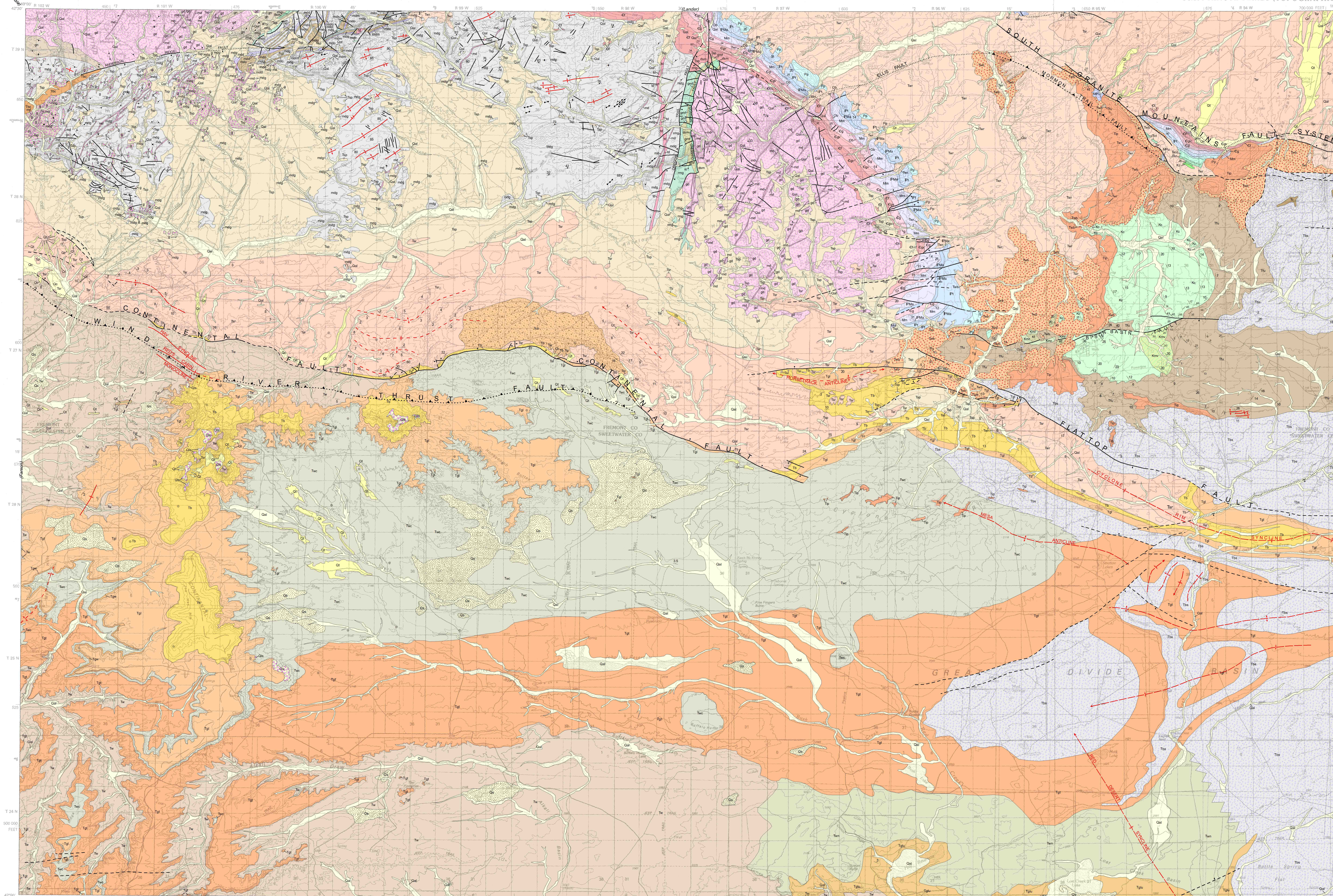
Geology - Interpreting the past to provide for the future

Prepared in cooperation with the
U.S. GEOLOGICAL SURVEY

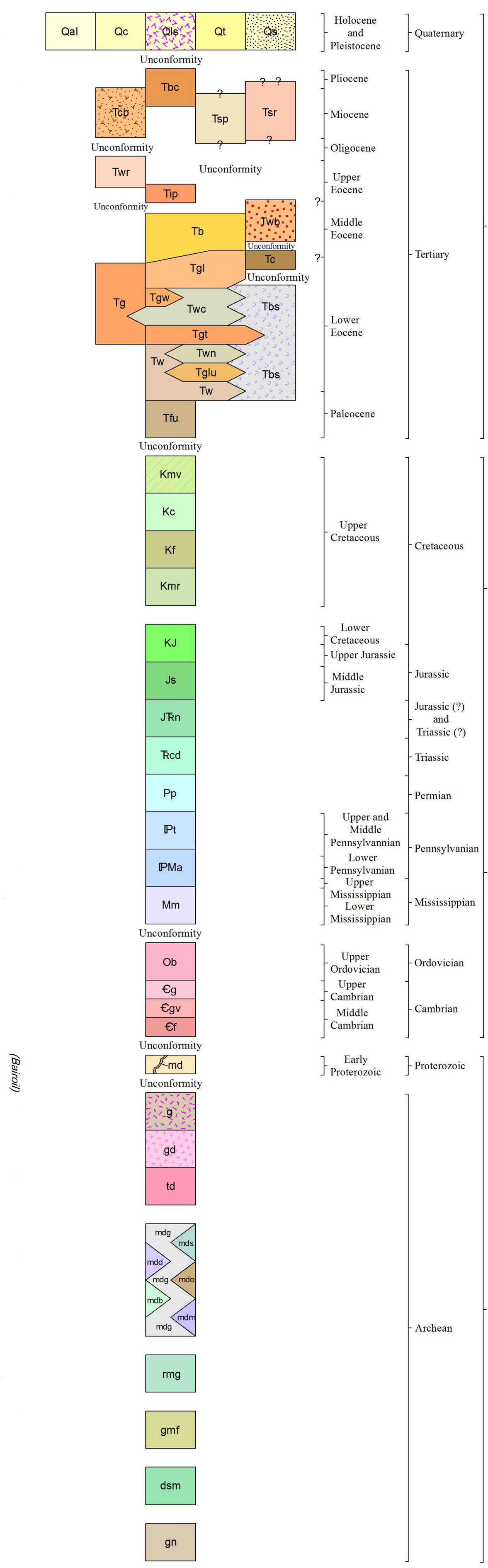
MAP SERIES 70
South Pass 1:100,000 - scale
Preliminary Geologic Map

SOUTH PASS, WYOMING

30X60 MINUTE SERIES (TOPOGRAPHIC)



CORRELATION OF MAP UNITS



MAP UNITS
(for complete descriptions of map units, see accompanying pamphlet)

Cenozoic units

Quaternary deposits

Qal	Alluvium
Qc	Colluvium
Qls	Landslide debris
Qt	Terrace, pedimant, and gravel deposits
Qs	Sand dunes

Tertiary sedimentory rocks

Tbc	Boulder conglomerate [Miocene-Pliocene (?)]
Tcb	Circle Bar beds [Miocene (?)]
Tsp	South Pass Formation (Miocene - Pliocene or lower miocene to (?) upper Oligocene[1])
Tsr	Split Rock Formation (Miocene - Pliocene or lower miocene to (?) upper Oligocene[1])
Twr	White River Formation (Oligocene or (?) upper Eocene[2])
Tip	Ice Point Conglomerate (upper Eocene)
Twb	Wagon Bed Formation (Eocene)
Tb	Bridger Formation (Eocene)
Tc	Crooks Gap Conglomerate (Eocene)
Tg	Green River Formation undivided (Eocene)
Tgl	Laney Shale Member
Tgw	Wilkins Peak Member
Tgt	Tipton Tongue and Tipton Shale Member
Tglu	Luman Tongue
	Wasatch Formation (Eocene)
Twc	Cathedral Bluffs Tongue
Twn	Niland Tongue
Tw	Main body of Wasatch Formation
Tbs	Battle Spring Formation (Eocene)
Tfu	Fort Union Formation (Paleocene)

Mesozoic sedimentary rocks

Kmv	Mesaverde Formation (Upper Cretaceous)
Kc	Cody Shale (Upper Cretaceous)
Kf	Frontier Formation (Upper Cretaceous)
Kmr	Mowry Shale (Upper Cretaceous)
KJ	Cloverly (Lower Cretaceous) and Morrison (Jurassic) formations, undivided
Js	Sundance Formation (Jurassic)
JTRn	Nugget Sandstone (Jurassic and Triassic)
TRcd	Chugwater (Triassic) and Dinwoody (Lower Triassic) formations undivided
MPu	Mesozoic and Paleozoic units undivided

Paleozoic sedimentary rocks

Pp	Phosphoria Formation (Permain)
IPt	Tensleep Sandstone (Pennslyvanian)
IPMa	Amsden Formation (Pennslyvanian and Mississippian)
Mm	Madison Limestone (Mississippian)
Ob	Bighorn Dolomite (Ordovician)
€g	Gallatin Limestone (Upper Cambrian)
€gv	Gros Ventre Formation (Middle Cambrian)
€f	Flathead Sandstone (Middle Cambrain)

Proterozoic rocks

Intrusive igneous rocks

md	Mafic dikes, 1,880-2,060 Ma (millions of years before present or mega-annum)

Archean rocks

Intrusive igneous rocks

g	Granite and granite pegmatite (includes South Pass pluton and Sweetwater granite); 2,545 ± 30 Ma
gd	Granodiorite (includes Louis Lake batholith and Lewiston Lakes pluton); 2,630 ± 20 Ma
td	Tonalite

Metasedimentary and metaigneous rocks of the South Pass greenstone belt

mdg	Miners Delight Formation metagreywacke; 2,800 Ma
mds	Graphitic schist
mdo	Mafic amphibolite
mdm	Mixed member (metavolcanics, metagreywacke, and schist)
mdb	Marble
mdd	Metadacite schist
rmg	Roundtop Mountain Greenstone
gmf	Goldman Meadows Formation (including iron formation)
dsm	Diamond Springs Formation

Gneiss complex

gn	Gneiss complex

[1] According to Lillegraven (1993) and Steidtmann and others (1986)

[2] According to Lillegraven (1993), the White River Formation has a North American Land Mammal Age of Chadronian (latest Eocene).

SYMBOLS

Contact

Fault – dashed where approximately located, dotted where inferred; ball and bar on downthrown side

Thrust fault – dashed where approximately located, dotted where inferred or projected beneath younger rocks; sawteeth on upthrown side

Anticline – dashed where approximately located

Overturned anticline – dashed where approximately located

Syncline – dashed where approximately located

Overturned syncline – dashed where approximately located

Monocline, anticlinal bend – inferred; shorter arrow indicates steeper beds

Monocline, synclinal bend – inferred; shorter arrow indicates steeper beds

Shear zone

Quartz vein

45 **Inclined bedding** – showing dip or general dip direction

Vertical bedding

Horizontal bedding

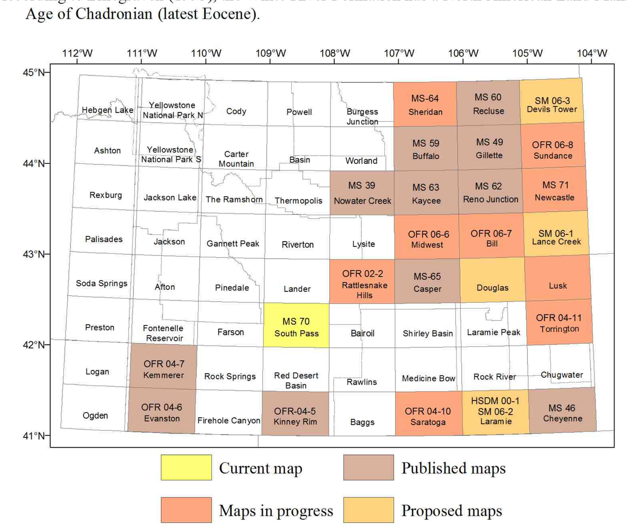
62 **Inclined foliation** – showing dip or general dip direction

Vertical foliation

Inclined jointing

Vertical jointing

Breccia zone

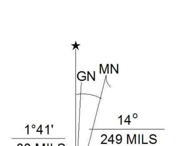


Current map
Published maps
Maps in progress
Proposed maps

Base map from U.S. Geological Survey South Pass, Wyoming 1:100,000 - scale metric topographic map, 1994.
Projection: Universal Transverse Mercator (UTM), zone 12
North American Datum of 1927 (NAD 27)
10,000-meter grid ticks: UTM, zone 12
25,000-foot grid ticks: Wyoming State Plane Coordinate System, west central zone

SCALE 1:100,000
Contour Interval 20 meters

0 1 2 4 6 8 10 12 14 16 18 20 Kilometers
0 1 2 3 4 5 6 7 8 9 10 11 12 Miles
0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000 18,000 20,000 Meters
0 5,000 10,000 15,000 20,000 25,000 30,000 35,000 40,000 45,000 50,000 55,000 60,000 65,000 Feet



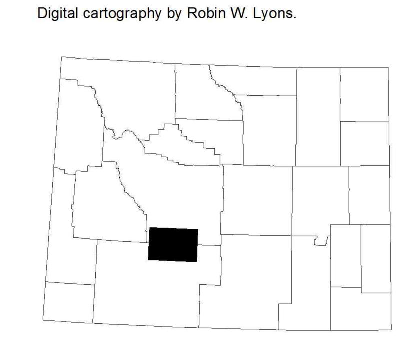
UTM GRID CONVERGENCE (GN)
1994 MAGNETIC DECLINATION (MN) AT CENTER OF SHEET
DIAGRAM IS APPROXIMATE

GEOLOGIC MAP OF THE SOUTH PASS 30' x 60' QUADRANGLE, FREMONT AND SWEETWATER COUNTIES, WYOMING

compiled by
Wayne M. Sutherland and W. Dan Hausel
2006

Prepared in cooperation with and research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under under USGS award numbers 04HQAG0045 and 05HQAG0062. the views and conclusions contained in this reportare those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

Digital cartography by Robin W. Lyons.



WYOMING
QUADRANGLE LOCATION

People with disabilities who require an alternative form of communication in order to use this publication should contact the Editor, Wyoming State Geological Survey. TTY Relay Operator 1 (800) 877 - 9975.

Additional copies of this map can be obtained from:
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Email: sales@wsgs.uwyo.edu

A digital version of this map is also available on CD - ROM.

DISCLAIMERS

SOUTH PASS 1:100,000 SCALE GEOLOGIC MAP

Wyoming State Geological Survey Map Series 70

Prepared in cooperation with the U.S. Geological Survey
2004 STATEMAP Grant award # 04HQAG0045
July 28, 2005

Wayne M. Sutherland and W. Dan Hausel

INTRODUCTION

The South Pass (1:100,000) quadrangle is located at the southern end of the Wind River Mountains, and includes part of the Red Desert, the Great Divide Basin, and the northeastern corner of the Green River Basin, Wyoming. The map encloses the community of Atlantic City, and the historic gold mining communities of South Pass City and Lewiston. The major drainage across the northern part of the map is the eastward-flowing Sweetwater River, and small streams flow westward toward the Green River from the far western part of the map area. The southern half of the map area drains southward into the Great Divide Basin, which is enclosed by the high ground of the continental divide.

Thirty-two 1:24,000 quadrangles that comprise the South Pass 1:100,000 scale map are listed as follows: Atlantic City, Anderson Ridge, Barras Springs, Buffalo Hump Basin, Bush Lake, Circle Bar Lake, Continental Peak, Cyclone Draw, Dickie Springs, Eagles Nest Draw, Five Fingers Butte, Five Fingers Butte NE, Freighter Gap, Happy Spring, Joe Hay Rim, John Hay Reservoir, Lewiston Lakes, Lost Creek Lake, Lost Creek Reservoir, Luman Rim, Monument Ridge, Olson Springs, Osborne Draw, Pacific Springs, Picket Lake, Radium Springs, Rock Cabin Spring, Soap Holes, South Pass City, Sulphur Bar Spring, The Pinnacles.

ECONOMIC GEOLOGY

Gold was discovered within the Lewiston district of the South Pass granite-greenstone belt in 1842. Following this, other discoveries were made in 1867 and later. Some high-grade gold was recovered from the Lewiston and the South Pass-Atlantic City districts including many sizable gold nuggets. One large 34-ounce nugget from this region now resides in the Los Angeles Museum of Natural History. Unfortunately, historical records and the whereabouts of many of the other South Pass nuggets are lacking.

In addition to gold, significant iron ore deposits were found along the northern edge of the South Pass greenstone belt. Some minor copper, silver, tungsten, uranium, asbestos, beryl, jade (?), aquamarine, ruby, and a diamond have also been reported within the South Pass 1:100,000 quadrangle. Development of the large taconite (iron ore) deposits in the 1950s led to the opening of the Atlantic City iron mine, immediately north of the map area, which produced more than 90 million tons of iron ore between 1962 and 1983 from banded iron formation in the Goldman Meadows Formation (Hausel, 1991). Extensive gold development took place across the entire Precambrian greenstone belt in the late 1860's to early 1870's, and again in the 1930's until World War II. Since that time, gold activity has been sporadic, encouraged by increasing gold prices, but inhibited during periods of unfavorable economic climate or by excessive environmental concerns. Lode deposits occur primarily in strike-trending shear zones within metagreywacke and hornblendic orthoamphibolites, and placer operations have developed at various times along most streams downstream from these shear structures (Hausel, 1989).

The South Pass greenstone belt still contains significant lode and placer gold, and most gold properties have never been thoroughly evaluated for potential to commercially produce gold in the modern world. Hausel (1991) reported that cursory investigations of the historic Carissa Mine during the late 1980's indicated that this mine alone hosted an identifiable reserve of more than 109,000 ounces averaging 0.343 to 0.850 oz/ton with a cutoff grade of 0.299 oz/ton (~ $46 million at today's gold prices). Scattered drilling results combined with a lack of deep drilling on this property indicate that this high-grade zone most likely is much more extensive along strike and at depth, and may include considerably more gold than identified by the limited drilling. In addition, the reported cutoff grade for the mineralized zone is very high, and lowering it to a reasonable limit with dramatically increase the reserve. The high cutoff grade combined with the essentially untested large tonnage low-grade mineralized zone associated with the property suggests that actual gold resources are much greater! Based on geology and the size of the shear structure, it has been suggested that that this property potentially could host more than one million ounces of gold (>$420 million at today's prices).

In addition to the Carissa property, a distinct belt of prospects and historic mines lies between the Carissa mine and Miners Delight mine along a 4 to 5 mile northeasterly trend in the greenstone belt. This belt provides a structurally favorable zone that could host a major gold resource. For example, mapping by Hausel (1991) identified numerous shear structures along with steeply plunging ore shoots associated with isoclinal and open folding that may be favorable for saddle reef-type gold mineralization. There is little evidence any of the historic operations recognized the steeply plunging structures as being significant, but based on mapping by Hausel (1991), these structures may be the key to understanding the gold mineralization in the region, and exploration of these structures could lead to several significant gold discoveries.

As detailed below in the description of the Cathedral Bluffs Tongue of the Eocene Wasatch Formation, that unit is estimated to host more than 28.5 million ounces of placer gold in the Dickie Springs-Oregon Gulch area with a current (2005) value of more than 12 billion dollars (Love, Antweiler, and Mosier, 1978; Hausel, 1991). This massive paleoplacer has been the subject of exploration in recent years.

Within the northeastern quarter of the map, boulders of apple-green, pink, and black nephrite jade were at one time common in the Ice Point Conglomerate in the vicinity of Ice Point. Apple-green jade boulders were also found within the Crooks Gap Conglomerate, but were not abundant (Love, 1970).

Excellent aquamarine beryl is known from a pegmatite in the South Pass Granite in the Anderson Ridge area in the northwestern corner of the quadrangle. Non-gem beryl is reported from several coarse-grained tourmaline-beryl granite pegmatites in the area (Hausel and Sutherland, 2000).

A placer diamond was reportedly recovered during the late 1800's from alluvial deposits along Beaver Creek, northeast of Atlantic City and just north of the South Pass 1:100,000 scale quadrangle. The position of this map within the south-central portion of the Archean craton coupled with kimberlite indicator mineral anomalies and known diamond host rocks elsewhere within the Wyoming Province suggests potential here for the discovery of diamonds and their host rocks (Hausel, 1998). No exploratory work has been conducted for diamond host rocks within the quadrangle.

The Greater Green River Basin, which includes the Great Divide Basin and encompasses the southern portion of the map, hosts abundant agate and petrified wood in the Laney Shale Member of the Green

River Formation and in the overlying Bridger Formation (Hausel and Sutherland, 2000). Silicification is not limited to these units and can be found to some extent in almost all the Tertiary formations here. Silicified algae, silicified oolites, some clear chalcedony, and moss agate are also found within the map area.

Small amounts of opal were reported by Sheridan, Maxwell, and Collier (1961) as accessory mineralization with schroeckingerite in the Lost Creek – Cyclone Rim area within the Eocene Battle Spring Formation and the Cathedral Bluffs Tongue of the Wasatch Formation, as well as within Quaternary surficial material. This area lies east of Lost Creek in parts of sections 29-33, T26N, R94W, and in part of section 25, T26N, R95W, along the Cyclone Rim zone of faulting. Opal was also reported by Bottjer (1984) as interstitial material in the South Pass Formation just west of the quadrangle.

Uranium mineralization in the form of schroeckingerite [$NaCa_3(UO_2)(CO_3)_3(SO_4)F \cdot 10H_2O$] was investigated in the Lost Creek Area by Sheridan, Maxwell, and Collier (1961). Prospect pits remain in various Tertiary units across the quadrangle as reminders of early uranium exploration. No current uranium exploration activity is known within the quadrangle.

In recent years, there have been reports of a significant ruby deposit in the vicinity of the Big Sandy opening northwest of the map area. Some corundum recovered in placers in this region has ranged from tiny grains to hexagonal grains up to 80 carats in weight.

Oil is produced from Jurassic and Upper Cretaceous formations in the Bison Basin field in the northeastern part of the quadrangle. Gas is produced from Upper Cretaceous units in several fields in the southeastern part of the quadrangle, and from lower Cretaceous units in a couple of small fields in the southwestern part of the quadrangle (De Bruin, 2002).

GEOLOGIC MAP UNITS

The geology for the South Pass 1:100,000 scale quadrangle was compiled from existing mapping and supplemented by aerial photo interpretation and cursory field checks. The rock units described here apply to the thirty-two 1:24,000 scale quadrangles that comprise the South Pass 1:100,000 scale quadrangle. These rock units were generalized and combined as expedience of the map scale. Similarly, some contacts between units, particularly Quaternary and Tertiary units, are uncertain, but are shown as solid rather than dashed lines.

Geologic units within the map area range in age from Archean to Quaternary. Major exposures of the South Pass granite-greenstone terrane (within the south-central portion of the Wyoming Province), at the southern end of the Wind River Mountains, are included within the northwestern and north-central parts of the South Pass 1:100,000 scale quadrangle. This elongate greenstone belt is characterized by Hausel (1991) as a synclinorium of metamorphosed volcanic, sedimentary and plutonic rocks that have been regionally metamorphosed to greenschist and amphibolite facies, and locally overprinted by a later retrogressive greenschist facies event. The axis of the belt is paralleled by foliation, shear zones, and lower order fold axes, and has been intruded along its flanks by granite and granodiorite.

The granite-greenstone belt forms the Precambrian core of the Wind River Range. The range was uplifted during the Late Cretaceous – Early Tertiary Laramide orogeny and was thrust westward and southward along moderately-dipping thrust faults. The high-angle normal Continental Fault trends eastward across the western part of the map north of Oregon Buttes, and generally marks the approximate surface location of the toe of the Wind River Thrust. The toe of this thrust, buried beneath Tertiary sediments, is shown more specifically for a short distance by Zeller and Stephens (1969).

Paleozoic and Mesozoic sediments dip northeast to east along the eastern flank of the Wind River Range, with some dipping southeast along the southeastern end of the range in the north-central part of the map (Bell, 1955). These units, along with minor Precambrian granite gneiss, are exposed in the northeastern part of the map near Crooks Mountain where elements of the southeast- to east-trending South Granite Mountains fault system cut units as young as the Miocene Split Rock Formation (Bell, 1955; Love, 1970). Upper Cretaceous formations are exposed in the Bison Basin (Buffalo Basin) area off the southeast end of the Wind River Range on both sides of the east-trending Bison Basin normal fault.

Tertiary formations comprise the majority of exposures within the South Pass 1:100,000 scale quadrangle, and no rock units older than Tertiary crop out within the southern half of the map. Abundant conflict exists in the description, designation, and mapping of Tertiary units within this quadrangle. This derives not only from their complex depositional and structural interrelationships, but also from the diverse perceptions of those involved in various mapping efforts. The Tertiary units depicted on this map represent a synthesis derived from previously published conflicting interpretations that cannot be fully resolved without extensive and detailed new field mapping that goes beyond the scope of this compilation.

QUATERNARY

Alluvium (Qal): Alluvium comprises unconsolidated sand, silt, clay, coarse gravels and cobbles, located in and along most drainages. This unit, compiled from many sources including air photo interpretation, may include eluvial deposits, lake sediments, slope wash and small alluvial and colluvial deposits (Qc) along drainages.

Colluvium (Qc): Colluvial deposits; includes some alluvial deposits and slope wash. Although such deposits are abundant in areas of steep slopes, they are depicted only in a few areas due to considerations of scale and depiction of bedrock rather than surficial geology.

Landslide debris (Qls): Locally derived landslide debris from unstable, generally steep slopes. This map unit was compiled from many sources (see references) and supplemented by air photo interpretation.

Terrace, pediment, and gravel deposits (Qt): Gravel covered terrace and/or cobble, sand, gravel and silt- covered terraces along mountain flanks and drainages. These terraces merge in places with eluvial, alluvial and colluvial deposits. Different terrace levels were not designated, although some areas have multiple levels of terraces. Some terraces may be equivalent to units previously mapped as pediment gravels or Pleistocene gravel deposits on some geologic quadrangles.

Sand dunes (Qs): Wind blown sand and sand dunes occur primarily within the western and southern portions of the quadrangle.

TERTIARY

Miocene Circle Bar beds (Tcb): These beds north of the Continental fault were informally designated and mapped by Jackson (1984) and rest with angular unconformity on top of the Bridger and Split Rock formations. Steidtmann and others (1986) described the Circle Bar beds as a fault scarp clastic wedge that is extremely localized in relationship to a fault-controlled topographic high that existed at the time of deposition. The Circle Bar beds consist of a 260- to 400-foot thick sequence of locally derived tuffaceous sandstone and conglomerate, accompanied by volcanic ash. The lower part is gray, fine-grained tuffaceous sandstone containing scattered pebbles of Precambrian rocks and sandstone boulders derived from the Split Rock Formation. The beds increase in coarseness upward and to the southwest into conglomerate interbedded with and cut into tuffaceous sandstone. Pebbles, cobbles, and boulders in the conglomerate include mafic metamorphic rocks and metagreywacke reworked from the adjacent Split Rock Formation along with Split Rock sandstone boulders as much as 9 feet in diameter (Steidtmann and others, 1986).

Miocene-Pliocene (?) boulder conglomerate (Tbc): Large white to gray granodiorite gneiss and granite boulders characterize this 2 to 3 mile long by ¼ mile wide arkosic conglomerate that appears to unconformably overlie the South Pass Formation (Hausel, 1986). This unit crops out parallel to and 2 miles northwest of Anderson Ridge in the northwest part of the South Pass 1:100,000 quadrangle.

Miocene-Pliocene [(?) late Oligocene-early Miocene] South Pass Formation (Tsp): The South Pass Formation is 0- to 350-foot thick, predominately arkosic, highly variable and poorly sorted unit composed primarily of pink to tan and gray, sandy, pebble- to boulder-sized (up to 3 feet in diameter) conglomerate. The majority of the material in the South Pass Formation was derived from Precambrian rocks in the Wind River Mountains to the north (Bottjer, 1984). Some interbedded sandstone, limestone, and volcanic ash described by Zeller and Stephens (1969) were not observed by Bottjer (1984). Pebbles and boulders are mostly Precambrian metagreywacke, diabase, and pegmatite within a fine-grained ashy sandstone matrix; locally, the conglomerate contains pebbles of moss agate (Zeller and Stephens 1969). Abundant secondary silica that is generally radioactive is the most distinctive feature of the South Pass Formation (Love, Antweiler, and Mosier, 1978).

This unit crops out north of the Continental fault in the northern part of the South Pass 1:100,000 quadrangle. Outcrops in the vicinity of the Flat Top Fault in T27N, R96W that were mapped as the Continental Peak Formation by Denson and Pipiringos (1974) are included within the South Pass Formation. The inclusion of these beds is based on their structural and stratigraphic relationships to adjacent units combined with their lithology as related to the characterization of the South Pass Formation by Bottjer (1984) and Steidtman and others (1986). Conglomerate that varies from 0 to 35 feet thick near the base of the 350-foot thick unit is dominated by cobbles of Paleozoic limestone, chert, and quartzite in a pink, fine-grained limy sandstone matrix, and is interpreted to represent a local lithofacies originating from the Wind River Mountains where the sediments had yet to be eroded from the core of the range. This interpretation is also in concert with Zeller and Stephens' (1969) characterization of the South Pass Formation as exhibiting heterogeneity and rapid changes in lithology, although they apparently did not work in the vicinity of these particular outcrops.

According to Zeller and Stephens (1969) the South Pass Formation unconformably overlies the Bridger Formation, the Arikaree [Split Rock] Formation and Precambrian rocks, and is overlain by Quaternary alluvium and pediment gravels. Denson and Pipiringos (1974) concurred in these field relations, positioning the "Pliocene and Upper Miocene South Pass Formation" above the "Ogallala and Arikaree" [Split Rock] formations. Jackson (1984) concluded that the South Pass predated the Split Rock. Love, Antweiler, and Mosier (1978) described the South Pass Formation as being Miocene to Pliocene in age. Zeller and Stephens (1969) also cited a late Miocene to middle Pliocene age for the unit.

However, using a “compromise reference timescale” based heavily on North American Land Mammal Ages as calibrated against a radiometric timescale, Lilligraven (1993) realigned Paleogene ages within Wyoming and placed the South Pass Formation as mid-to upper Arikarean (with minor uncertainty), encompassing much of the Miocene and the upper part of the Oligocene. Lilligraven (1993) also shows the Split Rock as being approximately the same age, or in places slightly younger than the South Pass formation. This is a readjustment from the earlier uncertain Miocene-Pliocene positioning of the South Pass Formation as shown on the stratigraphic nomenclature for Wyoming by Love, Christiansen, and Ver Ploeg (1993). Lilligraven’s age positioning of this unit also conflicts with Zeller and Stephen’s (1969) statement that “the formation unconformably overlies the Arikaree [Split Rock] Formation,” and with Denson and Pipiringos (1974) positioning of the South Pass Formation above the “Ogallala and Arikaree” [Split Rock] formations.

Steidtmann and others (1986) indicate a late Oligocene to early Miocene age for the unit coupled with an interfingering relationship to the Split Rock Formation. This fits with Lilligraven’s (1993) age relationships and conforms to a conclusion (demonstrated above) that field relations are confusing enough for several investigations to mistake complex interfingering of the South Pass Formation with the lithologically similar Split Rock Formation and to appear as if the South Pass was overlying (or conversely overlain by) the Split Rock.

Miocene [(?) late Oligocene-Miocene] Split Rock Formation (Tsr): The Split Rock Formation crops out north of the Continental Fault in the northern part of the South Pass 1:100,000 quadrangle and includes beds described by Love (1961; 1970). This unit was referred to in part as the Arikaree Formation by Zeller and Stephens (1969), and it was mapped as the Arikaree Formation and overlying Ogallala Formation by Denson and Pipiringos (1974) and includes some bed mapped as the Continental Peak Formation by Nace (1939) at Oregon Buttes and Continental Peak.. This unit was also mapped as the Split Rock Formation in the Circle Bar Lake quadrangle by Jackson (1984). Use of the name Split Rock Formation here conforms to the stratigraphic nomenclature for Wyoming as set down by Love, Christiansen, and Ver Ploeg (1993).

These investigators all subscribed to a Miocene age for the Split Rock Formation regardless of the name they applied to the unit. Steidtmann and others (1986) depict the age of the base of this unit as late Oligocene and extending through Miocene. Lilligraven (1993) concurs with Steidtmann (1986) in this adjustment for the age of the basal part of the formation.

Beaver Divide conglomerate & basal Split Rock conglomerates

Zeller and Stephens (1969) included a basal conglomerate in their Arikaree that was originally mapped by Nace (1939) as the Beaver Divide conglomerate. Nace described the Beaver Divide conglomerate as the base of what he called the Upper Chadron member, which he included within the White River Group [White River Formation]. He traced this conglomerate laterally into outcrops in the southern part of the Sweetwater Plateau that are continuous with the Beaver Divide conglomerate at Beaver Divide. Sheridan, Maxwell, and Collier (1961) described a conglomerate in the Lost Creek and Cyclone Rim areas that overlies the Bridger Formation and which they equated to Nace’s Beaver Divide conglomerate of ‘Oligocene(?)’ age. They also described a basal conglomerate in the Split Rock that overlies their equivalent of the Beaver Divide conglomerate. In the Cyclone Rim area, Denson and Pipiringos (1974) similarly include this conglomerate in the White River Formation, but map a larger White River outcrop than Sheridan, Maxwell and Collier (1961). Love (1970) also placed the Beaver Divide conglomerate near the base of the White River Formation.

Emry (1975) revised stratigraphy at Beaver Divide and clearly placed the Beaver Divide conglomerate within and near the base of the lower White River Formation. He stated that the conglomerate, made up of locally derived Precambrian crystalline clasts interbedded with ashy conglomeratic sandstone and accompanied by limited Paleozoic sedimentary clasts, does not represent the same stratigraphic interval at all locations, and grades upward into fine-grained, orange to gray, massive tuffaceous, silty sandstone siltstone, and claystone of the White River Formation. This opens the door for a different stratigraphic interpretation for the conglomerate at Oregon Buttes. Emry (1975) also separated out a volcanic conglomerate, found at Beaver Divide and previously included by various workers in the Beaver Divide Conglomerate, as a distal finger of the Wiggins Formation, and not a part of the Beaver Divide Conglomerate.

Although the situation at beaver divide seems clear, the stratigraphic position of the conglomerate, 40 miles distant at Oregon Buttes is still somewhat in question… it could be in the lower Split Rock Formation, in the White River Formation, or it may be a different conglomerate entirely... possibly a channel related to the South Pass Formation (Steidtmann, personal communication 2005). This report does not solve the conglomerate problems, but includes Nace's (1939) Beaver Divide conglomerate within the base of the Split Rock Formation in the Oregon Buttes – Continental Peak area in concert with most previous investigations in that part of the South Pass 1:100,000 quadrangle. In the Cyclone Rim area, the conglomerate equated to Nace's (1939) Beaver Divide conglomerate is included in the White River Formation as shown by both Sheridan, Maxwell and Collier (1961), and by Denson and Pipiringos (1974).

Stratigraphic relationships

The Split Rock Formation unconformably overlies the Eocene Bridger Formation at Oregon Buttes and at Continental Peak (Zeller and Stephens, 1969). The Split rock generally overlies the White River Formation with a marked erosional unconformity in the Granite Mountains area. However, in the Beaver Divide area, White River Formation strata are reworked into the basal part of the Split Rock and the contact is difficult to determine. Uncertainties in the Happy Spring area result in a stratigraphic 'discrepancy' of about 1000 feet in interpretation of this contact (Love, 1970). Maximum thickness of the Split Rock Formation within the South Pass 1:100,000 quadrangle is probably on the order of 2,100 feet.

Lithology

The Split Rock Formation comprises a wide-spread succession of soft, thick-bedded to massive, poorly-cemented, tan to light-gray quartz sandstone accompanied by smaller amounts of conglomerate, tuff, pumicite, claystone, and limestone. Discontinuous beds of altered volcanic ash are common and some beds are silicified (Love, 1961; Denson and Pipiringos, 1974; Love, 1970; Love, Antweiler, and Mosier, 1978).

The Split Rock Formation sandstones differ from all other Tertiary age sandstones in the vicinity in that they contain conspicuous well-rounded and frosted grains (Love, 1970). Much of the finer volcanic material within the formation is projected to have the Yellowstone - Absaroka area as a source (Van Houton, 1964; Love, 1970). Irregular chert nodules and silicious aggregates can be found throughout the formation.

The base of the Split Rock Formation at Oregon Buttes, Continental Peak, and where exposed adjacent to and north of the Continental fault is a 20- to 50-foot thick dark-gray conglomerate with angular clasts of Precambrian granite and metagreywacke, interbedded with ashy conglomeratic sandstone –

the conglomeratic sandstone is part of Nace's Beaver Divide conglomerate (Nace, 1939; Love, Antweiler, and Mosier, 1978). To the east in the Cyclone Rim – Soda Lake area, the Beaver divide conglomerate is included in the White River Formation, while the basal conglomerate of the Split Rock comprises intermittent lenticular conglomerates that grade upward into coarse- to fine-grained, gray and white sandstones accompanied by lenses of volcanic ash and gray to green marl and clay (Sheridan, Maxwell and Collier, 1961; Denson and Pipiringos, 1974). This part of the Split Rock is reported by Sheridan, Maxwell and Collier (1961) to be lithologically indistinguishable from the Split Rock Formation in the Granite Mountains near Split rock.

Oligocene [upper Eocene] White River Formation (Twr): The White River Formation crops out in the Cyclone Rim area and in the northeastern part of the South Pass 1:100,000 scale quadrangle. The White River Formation is Oligocene in age according to the stratigraphic nomenclature for Wyoming as set down by Love, Christiansen, and Ver Ploeg (1993). However, studies by Lilligraven (1993) interpret its age to be upper Eocene (Chadronian).

The White River Formation is composed of as much as 600 feet of white to grayish-orange and brown sandy tuffaceous siltstone and conglomerate and local beds of altered volcanic ash, with a 0- to 80-foot thick conglomerate at the base (Love, 1970; Denson and Pipiringos, 1974; Lilligraven, 1993). The White River unconformably, and in some places angularly, overlies The Ice Point Conglomerate, the Bridger Formation, the Wagon Bed Formation, and earlier rock units (Love, 1970). It directly ~~and~~ overlies the Bridger Formation in the Cyclone Rim area where it is about 100 feet thick, and is lithologically similar to Nace's Beaver Divide conglomerate at Oregon Buttes. The Beaver Divide Conglomerate was mapped in the Cyclone Rim area by Sheridan, Maxwell and Collier (1961), and subsequently mapped as the lower part of the White River Formation by Denson and Pipiringos (1974). The conglomerate here is made up of pebbles and boulders of sandstone, quartzite, and Precambrian igneous and metamorphic rocks within a fine- to coarse-grained quartz sand matrix.

Farther to the north, the basal conglomerate grades upward into white to grayish-orange, cliff-forming, massive fine-grained, silty sandstone accompanied by hard blocky siltstone and claystone. The formation contains abundant tiny black biotite flakes and glass shards, along with persistent thin and conspicuous pumicite beds. Angular grains within the White River are in marked contrast to the rounded grains in the overlying Split Rock, and the formation's general lack of clay contrasts strongly with the abundant clay characteristic of the underlying Wagon Bed Formation (Love, 1970).

Eocene Ice Point Conglomerate (Tip): The 0 to 200-foot thick Ice Point Conglomerate is described by Love (1970), and is named for exposures near Ice Point in Sec.3, T28N, R95W in the northeastern part of the South Pass 1:100,000 quadrangle where it forms resistant ridge caps. The Ice Point is uniquely conspicuous, and easily recognized, even where only a thin remnant of lag gravel remains. It was mapped and described in detail by Bell (1955) as "Eocene conglomerate", was mapped as "Browns Park (?) Formation" by Pipiringos (1961), and was mapped as "Conglomerate (Upper Eocene)" by Denson and Pipiringos (1974).

The Ice Point is composed of reddish-brown angular rock fragments ranging in size from pebbles to 10-foot diameter boulders within a brown to yellow to gray and cream, poorly cemented arkosic sandstone matrix, and is readily distinguishable from the conglomerates of the White River Formation. The larger materials include slabs of the quartzitic Cambrian Flathead Sandstone, fragments of Precambrian rocks, Cambrian limestone, Tensleep Sandstone, Permian cherts, and black petrified wood from unknown sources (Love, 1970). Bell (1955) noted that the conglomerate appears to rest on an erosion surface where it fills channels cut into underlying rock units, but it parallels the dip of underlying Eocene strata, dipping northward at 15 degrees in the Cyclone Rim area. About two miles northwest of Bison Basin, the Ice Point Conglomerate dips 14˚ northwest, and is angularly overlain by the horizontal White River Formation. Transport direction for material in this unit was southeastward, with thinning in that direction (Bell, 1955; Love, 1970). Remnants of the Ice Point form resistant ridge caps south, southwest, and southeast of Bison Basin. The percentage of rock fragments generally decreases in southward and southeastward direction, to the point that boulders are almost absent on the vicinity of Lost Creek (Bell, 1955).

Boulders of apple-green, pink, and black nephrite jade were at one time common in this unit in the vicinity of Ice Point (Love, 1970).

Eocene Wagon Bed Formation (Twb): This formation is found in widely dispersed outcrops in the northeastern part of the South Pass 1:100,000 quadrangle, and varies in thickness from 0 to 200 feet or more (Love, 1970). The Wagon Bed Formation unconformably overlies either lower Eocene, Paleocene, or pre-Tertiary rocks. It is unconformably overlain by the White River Formation and in places by the Split Rock Formation or by the South Pass Formation. The Wagon Bed Formation is in part equivalent to the Bridger Formation of the Green River and Great Divide basins in the southern part of the South Pass 1:100,000 scale quadrangle (Lilligraven, 1993; Love, Christiansen, and Ver Ploeg, 1993), and may interfinger with it.

The Wagon Bed Formation is dominated by persistent well sorted beds of yellowish-green to pale olive and dark greenish-gray sandstone, siltstone, and mudstone with abundant volcanic debris derived from the Yellowstone-Absaroka calc-akalic volcanic field. Ledge-forming, locally siliceous mudstones mark the base of the formation and are overlain in the Beaver Rim area by yellow to gray conglomeratic arkosic sandstone. The middle and upper parts of the formation contain light- to pale yellowish-gray coarse grained lapilli tuff, biotitic vitric tuff, and tuffaceous sandstone (Van Houten, 1964). The upper part of the formation contains some conglomerate beds with Paleozoic limestone and sandstone boulders up to 5 feet in diameter (Love, 1970).

This unit includes some beds mapped by Love (1970) as Wagon Bed Formation in T27N, R96W near the western extension of the Flattop Fault that are depicted by Denson and Pipiringos (1974) as an "intermediate transitional unit" with lithologies described as transitional in character between the Cathedral Bluffs and Red Desert Tongues of the Wasatch Formation and the Battle Spring Formation. Lithologic descriptions by Van Houton (1954) and Love (1970) support inclusion of these outcrops within the Wagon Bed Formation.

Eocene Bridger formation (Tb): The Bridger Formation crops out along the Continental Fault and at higher elevations near Continental Peak, Oregon Buttes, and along Hay Rim (Bradley, 1964; Welder and McGreevy, 1966). The Bridger Formation generally overlies, but in the lower parts interfingers with the Green River Formation, and in some places lies directly on top of the Wasatch Formation (Bradley, 1964). It is in part equivalent to the Wagon Bed Formation to the northeast (Love, Christiansen, and Ver Ploeg, 1993; Lilligraven, 1993). The Continental Peak formation as mapped by Nace (1939) at Oregon Buttes and Continental Peak is included within the top of the Bridger Formation (Zeller and Stephens, 1969; Bottjer, 1984).

The Bridger Formation comprises 245 to 800 feet of predominantly fluviatile sediments accompanied by extensive but thin layers of lacustrine sediments (Bradley, 1964). These sediments consist of light-gray, grayish-orange, pale-greenish-gray, white, and pink mudstone, tuffaceous claystone, and fine-grained sandstone, along with some thin-bedded shale and lacustrine algal limestone. A two-foot-thick algal limestone about 175 feet above the base of the formation serves as a marker bed, and is characterized by upright petrified tree stumps that are covered with algal layers. Another marker bed about 300 feet above the base of the Bridger is fifteen feet of thin-bedded fossiliferous dolomitic limestone that often weathers into two pronounced ledges (Zeller and Stephens, 1969). The Bridger is often poorly consolidated with lenticular beds that include chert layers, volcanic ash beds, and some marlstone (Sheridan, Maxwell, and Collier, 1961; Bradley, 1964; Zeller and Stephens, 1969). The Bridger often weathers into badlands topography, and the base of the unit can generally be picked at the beginning of such weathering (Sheridan, Maxwell, and Collier, 1961; Bradley, 1964).

Eocene Green River Formation (Tg): The Green River Formation as described by Bradley (1964) is a pile of lenses of lacustrine sediments within a large mass of shallow basin-filling fluviatile sediments that comprise the Bridger and Wasatch formations with which the Green River both intertongues and interfingers. Within the South Pass 1:100,000 quadrangle, the Green River formation is subdivided into four parts. The Laney Shale Member at the top of the formation that is underlain by the Wilkins Peak Member. The Wilkins Peak interfingers with the Cathedral Bluffs Tongue of the Wasatch Formation and overlies the Tipton Tongue of the Green River Formation. The Tipton overlies and partially interfingers with the Niland Tongue of the Wasatch Formation, which in turn overlies and partially interfingers with the Lumen Tongue of the Green River Formation. The Lumen Tongue overlies and partially interfingers with the main body of the Wasatch Formation (Bradley, 1964; Love, Christiansen, and Ver Ploeg, 1993). At its northeastern extent, in the Lost Creek area, the Tipton Tongue also interfingers with the Battle Springs Formation (Sheridan, Maxwell, and Collier, 1961; Bradley, 1964). Maximum thickness of the Green River Formation within the South Pass 1:100,000 quadrangle is on the order of 1230 feet or more (Denson and Pipiringos, 1974).

Laney Shale Member (Tgl): The Laney Shale Member is dominated by buff to brown, yellow, and gray, thinly laminated to massive shale, marlstone, and muddy sandstone, along with white to brown tuff and tuffaceous sandstone, thin algal limestone and oölite beds (Bradley, 1964). The Laney is about 150 feet thick at Oregon Buttes where the top is a silicified algal limestone. The Laney becomes thicker to the west, south, and east, and is about 225 feet thick near Honeycomb Buttes (Zeller and Stephens, 1969); total thickness may reach a maximum of 700 feet.

The upper part of the Laney consists of up to 275 feet of yellow, coarse-grained conglomeratic sandstone along with green and red variegated clayey shale that contains 2 inch- to 6 inch diameter pink lithographic limestone concretions. The lower part is as much as 425 feet thick, and predominantly consists of fissile, pale-green to yellowish-gray shale and siltstone with common beds of ostracod and mollusk coquina, and minor layers of sandstone and limestone (Denson and Pipiringos, 1974).

Wilkins Peak Member (Tgw): The Wilkins Peak Member is made up of greenish-gray to white, regularly- and thinly-bedded dolomitic mudstone, marlstone, and oil shale, accompanied by white to brown tuff and tuffaceous sandstone (Bradley, 1964). The Wilkins Peak only reaches about 35 feet in thickness within the South Pass 1:100,000 quadrangle where it crops out in the Oregon Buttes area as a prominent brilliant white-weathering band, devoid of vegetation (Zeller and Stephens, 1969). The Wilkins Peak is not found in the northern and eastern parts of the quadrangle, and pinches out southward in the southern part of T25N, R102W.

Tipton Tongue (Tgt): The Tipton Tongue, up to 350 feet thick, crops out across much of the southern and southeastern part of the South Pass 1:100,000 quadrangle (Bradley, 1964). The Tipton Tongue within the map area is composed in its upper half of light-bluish-gray, flaky organic marlstone, and soft buff to brown shale and organic marlstone in the lower half, with characteristic wide-spread algal layers in the middle part (Bradley, 1964).

Lumen Tongue (Tglu): The 180- to 500-foot thick Lumen Tongue crops out only near the southeastern edge of the South Pass 1:100,000 quadrangle. It comprises a series of brown interbedded fissile shale, oil shale, carbonaceous shale, grayish-green siltstone, and yellowish-gray limy sandstone beds that locally host thin coal seams (Bradley, 1964; Denson and Pipiringos, 1974).

Eocene Crooks Gap Conglomerate (Tc): This unit is made up primarily of very large (20 to 40 feet maximum dimension) granite boulders within poorly cemented pink to gray arkosic sandstone and siltstone. This conglomerate is distinguished from other middle and late Eocene and Oligocene age conglomerates by the absence of volcanic debris. Apple-green jade boulders were found within this conglomerate by Love (1970), but were not abundant. The Crooks Gap Conglomerate is found in the northeast part of the South Pass 1:100,000 quadrangle, and is about 400 feet thick based on fragmentary well records in the South Happy Springs oil field area. The Crooks Gap Conglomerate overlies both the main body of the Wasatch Formation and the Battle Springs Formation with angular unconformity, and suggested by to be the northern coarse clastic equivalent to the Cathedral Bluffs tongue of the Wasatch Formation (Love, 1970).

Eocene Wasatch Formation (Tw): The Wasatch Formation crops out across the southern half of the South Pass 1:100,000 quadrangle south of the Continental Fault where it underlies and intertongues with the Green River Formation. The Wasatch is subdivided into the Cathedral Bluffs Tongue, the Niland Tongue, and the main body of the formation (Bradley, 1964). The Cathedral Bluffs Tongue overlies and partially interfingers with Wilkins Peak Member of the Green River Formation and overlies the Tipton Tongue of the Green River Formation. The Niland Tongue of the Wasatch is found between the Tipton and the underlying Lumen tongues of the Green River Formation. The main body of the Wasatch crops out only in the south-central and southwestern portions of the quadrangle, and grades into or interfingers with its various tongues. The Wasatch within the map area varies in thickness from about 1650 to 2500 feet, and the Cathedral Bluffs Tongue complexly interfingers with the Battle Spring Formation to the east in the Lost Creek area (Sheridan, Maxwell, and Collier, 1961; Bradley, 1964).

The main body of the Wasatch formation is characterized by gray to green and occasionally bright red sandy mudstone irregularly interbedded with fine- to medium-grained, muddy calcareous sandstone, accompanied by carbonaceous shale and coal in the upper part, and grading into conglomerate near uplifts (Bradley, 1964).

Cathedral Bluffs Tongue (Twc): This upper unit in the upper Wasatch Formation is recognized only where it overlies the Tipton Tongue of the Green River Formation, and varies in thickness from 100 feet near the south end of Red’s Cabin monocline to greater than 700 feet on Pacific Butte, only 1 mile to the northwest (Steidtmann and others, 1986). The Cathedral Bluffs crops out extensively across the south-central portion of the quadrangle. Love, Antweiler, and Mosier (1978) estimated a thickness of 1300 feet east of Dickie Springs, and Sheridan, Maxwell, and Collier (1961) reported a thickness of 1650 feet in the Lost Creek area. The unit thins dramatically southward where it interfingers with the lake beds of the Green River Formation. The Cathedral Bluffs is coarser than, but similar to the main body of the Wasatch, and is made up of gray, green, and red arkosic siltstone, claystone, sandstone, and conglomerate (McGee, 1983; Bottjer, 1984). The conglomerate contains cobbles up to 10 inches in diameter of dark schist and gneiss accompanied by minor chert and quartz.

Locally, in two coarse conglomerate lobes, one near the Continental fault at Pacific Butte and the other east of Dickie Springs, the Cathedral Bluffs contains large granite boulders up to 15 feet in diameter. The matrix here is brown arkosic sandstone accompanied by fragments of schist and gneiss, as well as some ultramafic clasts concentrated east of Dickie Springs. These two conglomeratic lobes, particularly the eastern lobe, contain placer gold (Love, Antweiler, and Mosier, 1978; Hausel, 1991). Gold from these Wasatch conglomerates has been reworked and concentrated into significant Quaternary deposits referred to as the historical Dickie Springs-Oregon Gulch gold placers. The reworked placer gold is relatively coarse, with some particles exceeding 0.2 inches in diameter. Love, Antweiler, and Mosier's (1978) reconnaissance sampling showed gold values in the eastern lobe of 62.5 milligrams per cubic meter over an area of about 8 square miles. From this, they estimated that the total value of the paleoplacer would exceed 5 billion dollars at a gold price of $175/oz. At today's value of about $420/oz, (2.4 x the 1978 value) that equates to more than 12 billion dollars!

Niland Tongue (Twn): The Niland Tongue crops out in the southeastern portion of the quadrangle, merges imperceptibly to the west with the main body of the Wasatch Formation, and interfingers with the Battle Springs Formation to the east. The Niland reaches a maximum thickness of about 400 feet within the map area, and is composed of greenish-gray to white lenticular sandstone and gray mudstone interbedded with carbonaceous shale and subbituminous coal (Bradley, 1964).

Eocene Battle Spring Formation (Tbs): The Battle Spring Formation, crops out in the eastern part of the South Pass 1:100,000 quadrangle and interfingers with the Wasatch and Green River formations to the west. Contacts with adjacent formations are gradational, both horizontally and vertically (Denson and Pipiringos, 1974). The Battle Spring consists of 3300 feet or more of light-gray to brown, coarse-grained to pebbly arkosic sandstone, and conglomerate, accompanied by greenish-gray sandy clay and mudstone. It locally contains large sandy, iron-rich spheroidal concretions (Sheridan, Maxwell, and Collier, 1961; Bradley, 1964). This unit includes some beds in the Cyclone Rim area that were mapped by Denson and Pipiringos (1974) as an "intermediate transitional unit" with lithologies described as transitional in character between the Cathedral Bluffs and Red Desert Tongues of the Wasatch Formation and the Battle Spring Formation. These intertonguing lithologies with gradational contacts are partly included within the Cathedral Bluffs Tongue of the Wasatch Formation and partly included within the Battle Spring Formation separated by an approximate boundary determined from interpretation of color IR imagery.

Additionally, some beds in T27N, R96W near the western extension of the Flattop Fault that were depicted by Denson and Pipiringos (1974) as part of their "intermediate transitional unit" are mapped as Wagon Bed Formation in concert with mapping by Love (1970) and with lithologic descriptions by Van Houton (1954) and Love (1970).

Paleocene Fort Union Formation (Tfu): The Fort Union is composed of 800 to 2,700 feet of dull gray to brown soft claystone, very fine- to coarse-grained fluviatile and lacustrine sandstone and varicolored siltstone accompanied by lenticular interbeds of carbonaceous shale and coal. Outcrops of the Fort Union in the Bison Basin area are typified by smooth drab slopes of gray to brown claystone between lenticular conglomerate beds (Love, 1970). Locally, near the south end of the Wind River Range, the Fort Union contains massive hard siliceous beds of conglomerate dominated by pebbles of Paleozoic and Mesozoic black chert, limestone, and quartzite (Welder and McGreevy, 1966; Love, 1970; Denson and Pipiringos, 1974).

MESOZOIC

Upper Cretaceous Mesaverde Formation (Kmv): The Mesaverde Formation is a predominantly nonmarine sequence of gray and brown, fine- to medium-grained, cross-bedded sandstone interbedded with shale, carbonaceous shale, and coal (Hares, 1946; Love, 1970). The 800 to 1200 foot thick Mesaverde Formation overlies, and partially intertongues with the Cody shale (Barwin, 1961). The Mesaverde crops out east of Bison Basin in the east central part of the map.

Upper Cretaceous Cody Shale (Kc): The Cody Shale, approximately 4000 feet thick within the map area, is predominantly soft dark-gray fissile shale with numerous bentonite and bentonitic shale beds in the lower part. This offshore marine sequence is sandier in the upper part, and contains thin calcareous siltstone, fissile sandstone, and irregular concretionary sandstone beds in the upper few hundred feet. It is more limy in the lower part where it contains several thin persistent sandstone beds (Hares, 1946; Love, 1970). The Cody intertongues with the overlying Mesaverde Formation (Barwin, 1961). The Cody Shale crops out in the vicinity of Bison Basin in the northeast part of the South Pass 1:100,000 scale quadrangle.

Upper Cretaceous Frontier Formation (Kf): The Frontier Formation is made up of 800 to 900 feet of black to dark gray shale and siltstone interbedded with gray and brown fine- to coarse-grained sandstone that is most abundant in the upper half. White to yellow bentonite and tuff beds are common in the lower half of the formation along with some thin impure coal beds (Hares, 1946; Love, 1970). The Frontier Formation crops out two locations in the northeast corner of the South Pass 1:100,000 scale quadrangle: near Bison Basin, and south of Happy Springs.

Upper Cretaceous Mowry Shale (Kmr): The Mowry consists of 250 to 300 feet of hard, black, weathering to silver-gray, siliceous and tuffaceous shale that contains abundant fish scales and numerous bentonite beds (Hares, 1946; Love, 1970). It crops out in two locations in the northeast corner of the South Pass 1:100,000 scale quadrangle: near Bison Basin, and south of Happy Springs.

Lower Cretaceous Cloverly Formation (Kcv): The Cloverly Formation is buff to gray, brown-weathering, fine-grained, crossbedded, slabby sandstone interbedded with soft, brightly variegated plastic claystone in the upper part. This is underlain by gray silty sandstone interbedded with dully variegated silty claystone in the lower part. Thickness is about 350 to 400 feet thick (Love, 1970). The Cloverly Formation crops out only in the northeastern corner of the map.

Jurassic Sundance Formation (Js): The Sundance Formation hosts 200 to 500 feet of pale-green to brown and buff, fine-grained, partially glauconitic sandstone interbedded with gray to green glauconitic limestone in the upper part. The lower part contains gray to pink very fine-grained sandstone interbedded with gray, thin fossiliferous limestone beds (Welder and McGreevy, 1966; Love, 1970; Keefer, 1970). The Sundance Formation lies unconformably on top of the Nugget Sandstone. The Sundance Formation crops out only in the northeastern corner of the map, south of Happy Springs.

Jurassic / Triassic Nugget Sandstone (Jn): The Nugget Sandstone is made up of 400 to 500 feet of cream to buff and salmon-red, massive to cross-bedded, fine- to medium-grained sandstone. The Nugget is extensively cross-bedded in the upper part and contains abundant frosted, rounded quartz grains (Love, 1970; Keefer, 1970). The Nugget Formation crops out only in the northeastern corner of the map south of Happy Springs .

Triassic Chugwater & Lower Triassic Dinwoody Formations (dcd): The Chugwater and Dinwoody Formations, with a combined thickness of about 1200 feet are mapped together in two poor exposures in the northeastern part of the map area. The Chugwater comprises approximately 1100 feet of red and orange to purplish-gray siltstone interbedded with partially cross-bedded, fine- to medium-grained sandstone(Love, 1970). The resistant, thin-bedded, 15-foot thick gray to pinkish-gray Alcova Limestone Member occurs about 800 feet of the base of the formation (Keefer, 1970).

Below the Chugwater, the Dinwoody Formation consists of 50 to 100 feet of slope-forming, thin-bedded yellow- to tan-weathering dolomitic siltstone and very fine-grained gypsiferous sandstone (Keefer and Van Lieu, 1966; Love, 1970). The Dinwoody is equivalent to the upper part of the Goose Egg Formation (Keefer, 1970; Love, Christiansen, and Ver Ploeg, 1993). Although the lithology changes markedly at the contact, Dinwoody appears to conformably overlie the Phosphoria Formation (Keefer and Van Lieu, 1966).

PALEOZOIC/MESOZOIC

Paleozoic and Mesozoic units undivided (PMu): Small areas of Paleozoic and Mesozoic formations of all types are combined where not mapped individually on the north central part of the map.

PALEOZOIC

Permian Phosphoria Formation (Pp): Within the South Pass 1:100,000 quadrangle, the Phosphoria Formation is represented by about 325 feet of tan to buff, brown, gray, and black interbedded chert, limestone, dolomite and siltstone, very fine sandstone, and thin beds of phosphate rock and shale, with a thin (5-15 feet thick) basal conglomerate present in many localities. Tubular twisted masses of chert are abundant within thick-bedded limestone in the upper half of the formation, and are a characteristic feature of the Phosphoria. The upper carbonates and cherts erode to prominent dip slopes that are devoid of trees in a marked contrast to the underlying Tensleep Sandstone. The Phosphoria is separated from the underlying Tensleep by an erosional unconformity (Keefer and Van Lieu, 1966). The Phosphoria Formation (referred to in the past as the Park City Formation) is interbedded with, and grades into the lower part of the Goose Egg Formation to the east (Love, Christiansen, and Ver Ploeg, 1993).

Pennsylvanian Tensleep Sandstone (ht): The Tensleep within the map area consists of about 600 feet of uniform, resistant cliff-forming buff to tan, cream, white, and gray massive, fine- to medium-grained, cross-bedded sandstone with a few thin gray cherty limestones and dolomites in the lower part ((Keefer and Van Lieu, 1966; Pekarek, 1977; Love and others, 1979). The formation weathers brown to rusty-brown, and may appear almost black, and is usually accompanied by coarse blocky talus at the base of cliffs. The Tensleep Sandstone appears to lie conformably on top of the Amsden Formation where the contact is not obscured by talus (Keefer and Van Lieu, 1966).

Pennsylvanian Amsden Formation (ha): The Amsden Formation is about 300 feet thick in the northern part of the South Pass 1:100,000 quadrangle. The lower part of the formation is made up of interbedded red shale, siltstone, and sandstone, with a 15-foot to 30-foot thick, thin-bedded basal sandstone. On top of this lower sequence, the Amsden often exhibits a 40-foor thick red shale containing hematite nodules. The upper part of the Amsden is a variable sequence of gray to buff, red and green, massive to thin-bedded cherty limestone and dolomite, fine-grained quartzitic sandstone, and shale occasionally separated by slight disconformities. The Amsden Formation shows a pronounced erosional unconformity in its contact with the underlying Madison Limestone (Keefer and Van Lieu, 1966).

Mississippian Madison Limestone (Mm): The Madison Limestone represents about 235 feet of massive to thin-bedded bluish-gray crystalline to limestone and dolomitic limestone accompanied in places by massive to bedded chert and abundant chert nodules. The Madison also exhibits some angular limestone breccia in an earthy-red matrix that stains many outcrops. This represents only the lower part of the formation as described farther north. The Madison thins from the northwest to the southeast, and the upper part of the formation is essentially absent within the map area, probably due to post-Madison erosion. The Madison Limestone here unconformably overlies the Gros Ventre Formation, an the contact often exhibits several feet of relief (Keefer and Van Lieu, 1966).

Ordovician Bighorn Dolomite (Ob): The Bighorn Dolomite is only about 20 feet thick where exposed in the far northern part of the South Pass 1:100,000 quadrangle. It thins out southward, and is not mapped in the southern part of the Paleozoic exposures along the southeastern flank of the Wind River Mountains. The Bighorn unconformably overlies the Gallatin Limestone. It is a uniform, very resistant, cliff-forming, light gray to buff, massive granular dolomite that weathers with a characteristic rough and sharp pitted surface (Keefer and Van Lieu, 1966).

Cambrian Gallatin Limestone (єg): The Gallatin Limestone is 250 to 330 feet thick within the South Pass 1:100,000 scale quadrangle, and generally forms prominent cliffs above the sloping outcrops of the Gros Ventre Formation. The formation includes about 85 feet of gray thin-bedded glauconitic and oolitic limestone with some flat-pebble conglomerate in its lower part, referred to as the Du Noir Limestone Member that in places grades rapidly into the underlying Gros Ventre Formation clastic sediments. Above this limestone is the Open Door Limestone Member, which comprises about 25 feet of thin white sandstone and red siltstone beds accompanied by minor thin-bedded gray limestone overlain by as much as 250 feet of gray, hard, resistant thin-bedded to massive limestone and a few flat-pebble conglomerate beds. The upper-most part of the Open Door Member is characteristically mottled with small irregular masses of tan granular limestone that weather in a rough, pitted manner similar in appearance to the overlying Bighorn Dolomite (Keefer and Van Lieu, 1966).

Cambrian Gros Ventre Formation (єgv): The Gros Ventre Formation is nonresistant, generally poorly exposed, and is about 500 feet thick. The Gros Ventre is primarily composed of reddish-orange to red, brown, and gray interbedded very fine grained sandstone and shale accompanied in the upper half of the formation by numerous thin limestone beds and layers of flat pebble conglomerate (Keefer and Van Lieu, 1966). The Gros Ventre Formation conformably, and in places gradationally overlies the late Middle Cambrian Flathead Sandstone.

Cambrian Flathead Sandstone (єf): The Flathead consists of about 350 feet of resistant reddish-brown to pink, gray, and tan, fine- to coarse-grained, often thinly-laminated, and occasionally cross-bedded quartzitic sandstone that commonly contains glauconite and hematite. The upper part of the formation tends to be more shaley and softer than the lower part. The base of the formation is commonly conglomeratic and arkosic with angular fragments of mica, feldspar and quartz, and some granitic pebbles up to one inch across (Keefer and Van Lieu, 1966). The Flathead unconformably overlies Precambrian igneous and metamorphic rocks.

PRECAMBRIAN

Terminology and unit designations are based on those used by Hausel (1991) for the South Pass granite-greenstone belt of the southern Wind River Range, with details added from numerous other sources shown in the attached references.

PROTEROZOIC

Early Proterozoic mafic dikes, 1880-2060 Ma (md): Predominantly northeast- to east-trending, 10 to 200-foot wide and up to several mile-long, fine- to medium-grained mafic dikes. These show chilled selvages, and are tholeiitic basalts and diabases with equigranular, porphyritic. And polotaxitic textures. An age of 1880-2060 Ma is reported by Spall (1971) for mafic dikes in the Louis Lake area. A wider age spread of 1270-2010 Ma reported by Condie and others (1969) for mafic dikes in the Wind River Range that may relate to one or more younger non-rock-forming thermal disturbances (Spall, 1971; Stuckless, 1989).

ARCHEAN

granite and granite pegmatite, 2545 ± 30 Ma (g): This includes two granitic plutons that intrude metasedimentary rocks of the Miners Delight Formation in the western part of the greenstone belt. The South Pass pluton is a pegmatitic granite west of South Pass City, and the Sweetwater granite is a fine- to medium-grained leucocratic granite that occurs to the west of the South Pass pluton along the Sweetwater River and Lander Creek. These may both be part of the larger Bears Ears pluton (Hausel, 1991). Stuckless and others (1985) found U-Pb ages from zircons of 2504 ± 40 to 2575 ± 50 Ma for the Bears Ears Pluton. Stuckless (1989) estimated the best age for the Bears Ears pluton at 2545 ± 30 Ma, and noted that calculated age differences may be attributed to isotopically inhomogeneous magma at the time of intrusion. He also related that the Bears Ears Pluton protolith may be younger than the Louis Lake Batholith, probably crystallized at lower pressures, and may have experienced high-grade metamorphism prior to derivation of the granitic magma.

granodiorite, 2630 ± 20 Ma (gd): Hausel (1991) cites isotopic studies after Hull (1988) that date the formation of the Louis Lake batholith at 2630 ± 20 Ma from a 3.5 Ga tonolite protolith. Stuckless and others (1985) and Stuckless (1989) compiled U-Pb ages from zircons along with Th-Pb, U-Pb, Pb-Pb, and Rb-Sr whole-rock ages, and noted a K-Ar hornblende age of 2640 Ma (Bayley and others, 1973), but argued that K-Ar biotite and Rb-Sr ages by various workers are all a bit younger.

tonalite (td): The first granitic event in the South Pass area includes tonalite dikes and plugs intruded into shear zones in the South Pass supracrustal rocks along with light-colored, metamorphosed leucodacite porphyry and quartz diorite. This unit is exposed in small areas near the Mary Ellen mine, just west of the Duncan mine, and in a 6-mile long north-trending intrusion east of Lewiston. A quartz vein included within the Mary Ellen stock carries visible gold, and a quartz stringer within sheared metaleucodacite porphyry dike just north of the 1:100,000 scale map boundary contained disseminated arsenopyrite, and showed 0.01 oz/ton gold along with 0.01 oz/ton silver (Hausel, 1991).

South Pass Greenstone Belt Metasedimentary and Metaigneous Rocks

Miners Delight Formation metagreywacke, 2.8 Ga (mdg): The diverse lithology of the Miners Delight Formation, ranging in thickness from a minimum of 5000 feet to as much as 20,000 feet (Bayley and others, 1973), is dominated by gray to dark brown feldspathic and biotitic metagreywacke, and mica schist. An Rb-Sr whole-rock isochron of about 2.8 Ga reported for the greywacke by Stuckless and others (1985). The contact between the Miners Delight formation and the Roundtop Mountain Greenstone is the Roundtop fault, which is locally marked by mylonitized, brecciated, and strongly folded rocks. The Miners Delight formation hosts several epigenetic shear zone and vein gold deposits, and is subdivided into several lithologic units, the relative ages of which are not known, and are not to be implied by the following order of discussion.

graphitic schist within the Miners Delight Formation (mds): Black, commonly sheared and iron-stained schist, containing quartz stringers, veins, and gold mineralization

mafic amphibolite within the Miners Delight Formation (mdo): Black, fine- to medium-grained hornblendic amphibolite that includes metamorphosed gabbro dikes and sills and basalt flows. This unit locally hosts auriferous shear zones.

mixed member within the Miners Delight Formation (mdm): This mixed member comprises fine-grained mafic metavolcanics, metagreywacke, chlorite schist, tremolite-actinolite schist, and local interbeds of metaconglomerate.

marble within the Miners Delight Formation (mdb): This is fine- to medium-grained, locally sulfide-bearing metacarbonate.

metadacite within the Miners Delight Formation (mdd): Black metadacite porphyry flows and possibly sills exhibit plagioclase phenocrysts aligned in a trachytic texture.

Roundtop Mountain Greenstone (rmg): The Roundtop Mountain Greenstone is predominantly greenstone, greenschist, and amphibolite, but also includes mica schist, hornblende-mica schist, and metabasalt, accompanied by minor metagreywacke, metatuff, chlorite schist, tremolite-actinolite schist,, and rare grunerite schist. The unit is exposed on both limbs of the South Pass synclinorium, and in most places conformably, but locally unconformably, overlies the Goldman Meadows Formation. Much of the unit is composed of metamorphosed pillow basalts and cusp-shaped pillow structures are preserved on Roundtop Mountain. A broad zone of carbonated breccias and intensely folded schists, representing a major break in the geologic record, is found at the top of the formation (Hausel, 1991).

Goldman Meadows Formation (gmf): The Goldman Meadows Formation overlies the Diamond Springs Formation and contains two distinct lithologies: a schist member that includes pelitic schists, quartzites and massive to schistose amphibolites; and iron formation members composed of banded quartz-magnetite-amphibolite iron formation. The iron formation consists of laminated dark gray to black, fine-grained, hard, dense alternating 0.1 to 2.0 inch-thick layers of magnetite and metachert and varying amounts of amphibole. The average iron content in the Atlantic City area is about 33.5% and ranges as high as 56.23% (Bayley, 1963).

Diamond Springs Formation (dsm): The Diamond Springs Formation is conformable with the overlying rocks and consists predominantly of serpentinite, tremolite-talc-chlorite schist, and amphibolite. Compositionally, these rocks are typical of the basal volcanic members in other Archean terranes, and represent high-magnesian, sub-marine flows and sills (Hausel, 1991).

Gneiss Complex

gneiss complex (gn): Felsic gneiss and granite migmatite, interlayered with supracrustal rocks and intruded by granodiorite, is intercalated in places with the supracrustal rocks of the greenstone belt. Hausel (1991) suggests that the likely origin for this unit is an ancient basement or earlier supracrustal succession tectonically interleaved as thrust splinters into the South Pass supracrustals.

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