WYOMING STATE GEOLOGICAL SURVEY
Lance Cook, State Geologist
Laramie, Wyoming

Geology - Interpreting the past to provide for the future

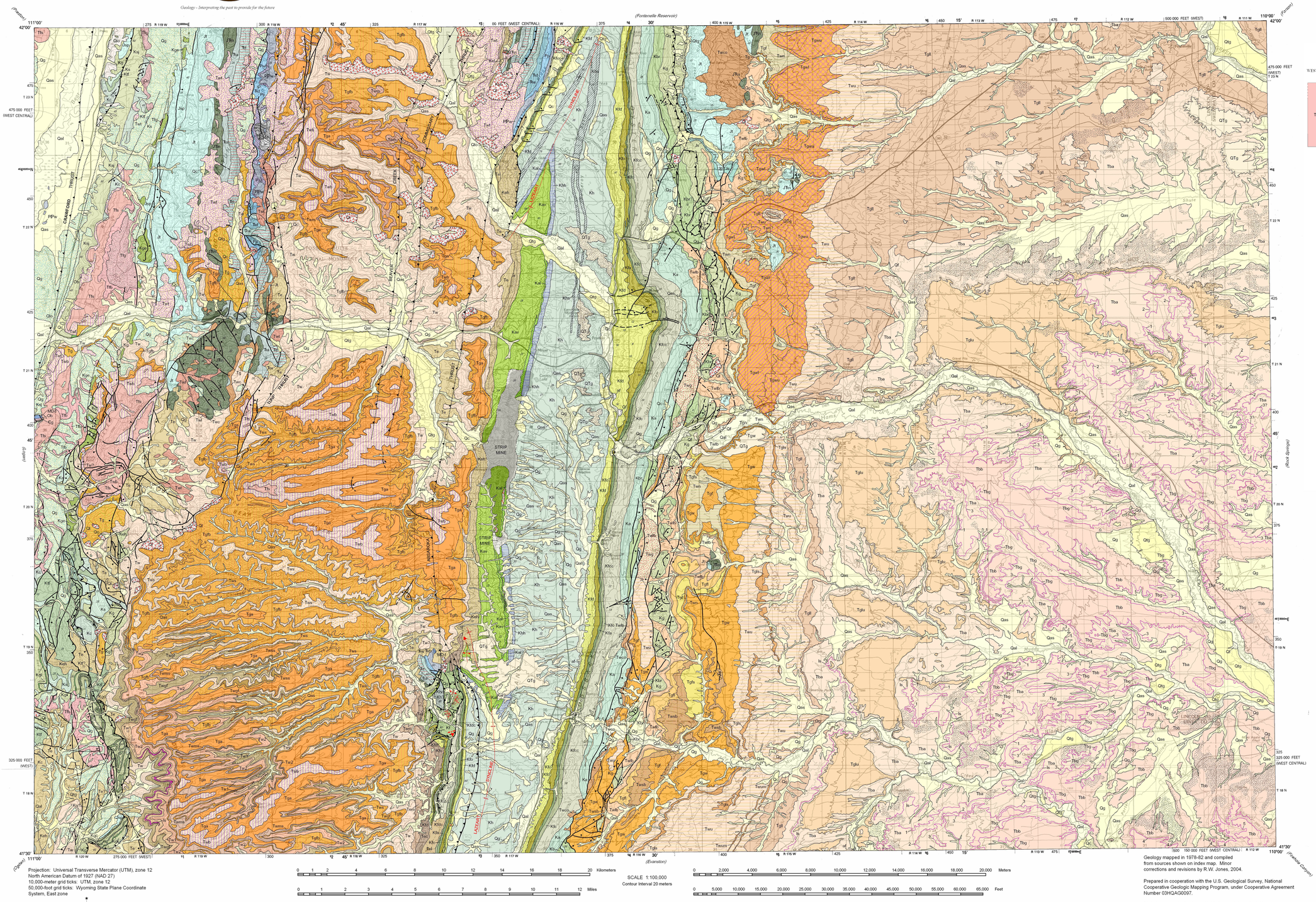
USGS science for a changing world

Prepared in cooperation with the U.S. GEOLOGICAL SURVEY

OPEN FILE REPORT 04-7
Kemmerer 1:100,000 - scale Geologic Map
Sheet 1 of 2

GEOLOGIC MAP OF THE KEMMERER 30' x 60' QUADRANGLE, LINCOLN, UINTA, AND SWEETWATER COUNTIES, WYOMING

By
J.W. M'Gonigle and J.H. Dover, 2004
digitized from J.W. M'Gonigle and J.H. Dover, 1992



Projection: Universal Transverse Mercator (UTM), zone 12
North American Datum of 1927 (NAD 27)
10,000-meter grid ticks: UTM, zone 12
50,000-foot grid ticks: Wyoming State Plane Coordinate System, East 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

GN MN
1°02'
18 MILS
14°
249 MILS

UTM GRID CONVERGENCE (GN)
1982 MAGNETIC DECLINATION (MN) AT CENTER OF SHEET
DIAGRAM IS APPROXIMATE

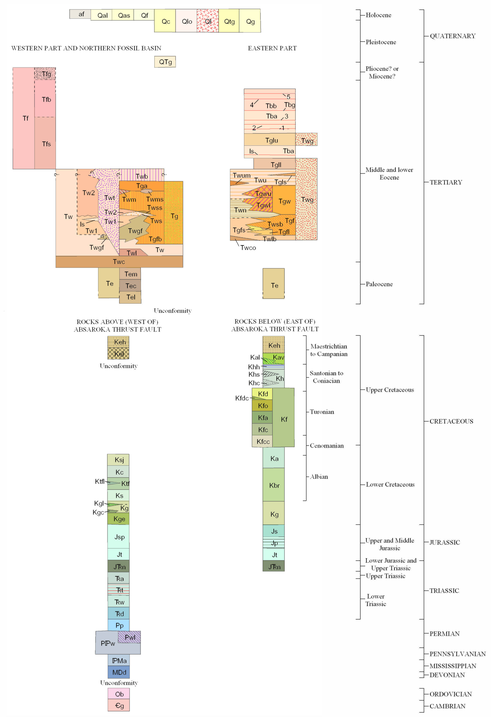
Geology mapped in 1978-82 and compiled from sources shown on index map. Minor corrections and revisions by R.W. Jones, 2004.

Prepared in cooperation with the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under Cooperative Agreement Number 03HQAG0097.

Digital cartography by Justin M. Mulbay and Joseph M. Huss

EXPLANATION

CORRELATION OF MAP UNITS

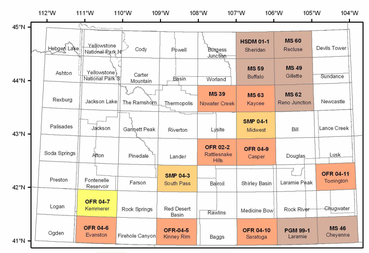


MAP SYMBOLS

- **Contact**—Dashed where approximately located; dotted where concealed; queried where uncertain
- **High-angle fault**—Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side
- **Thrust or reverse fault**—Dashed where approximately located; dotted where concealed; queried where uncertain. Sawteeth on upper plate
- **Fold**—Showing crestline and direction of axial plunge
- **Anticline**
- **Overturned anticline**
- **Syncline**—Dotted where concealed
- **Overturned syncline**

Strike and dip of bedding

- **Inclined**
- **Overturned**
- **Vertical**
- **Trace of bedding or marker bed**
- **Limestone or marlstone bed**—Arrow indicates pinchout of bed
- **Sandstone bed**—Arrow indicates pinchout of bed
- **Boundary of strip mine**
- **Landslide scarp**—Hachures point downslope
- **Clinker**—Area of naturally burned coal bed
- **Sand dune area**—Pattern indicates approximate boundary (Data from A.B. Gibbons, written communication, 1951)



Current map
Published maps
Maps in progress
Proposed maps

INDEX TO 1:100,000-SCALE BEDROCK GEOLOGIC MAPS OF WYOMING

KEY TO ABBREVIATIONS
Wyoming State Geological Survey maps: Map Series (M), Open File Report (OFR), Preliminary Geologic Map (PGM), and unpublished STATEMAP project (SMP).

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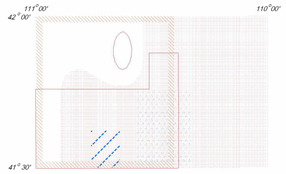

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- Schroeder, 1981, scale 1:24,000
- Schroeder and Lunceford, 1979, scale 1:24,000
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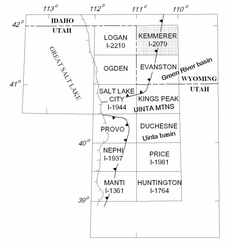
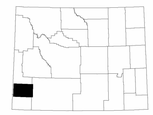


- East margin of thrust belt
- East margin of basin and range province

MAP SHOWING LOCATION AND TECTONIC SETTING OF THE KEMERRER 30' x 60' QUADRANGLE (SHADED) AND OTHER PUBLISHED 30' x 60' GEOLOGIC MAPS



WYOMING
QUADRANGLE LOCATION

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OPEN FILE REPORT 04-7
Kemmerer 1:100,000 - scale Geologic Map
Sheet 2 of 2

DESCRIPTION OF MAP UNITS

Surficial deposits

af — **Artificial fill (Holocene)**

Qal — **Alluvium (Holocene and upper? Pleistocene)**—Unconsolidated, crudely to well-stratified clay, silt, sand, and gravel deposited along present main streams, primarily as channel-fill and flood-plain deposits; locally includes alluvial-fan and terrace deposits, valley-side colluvium or talus, and sediments deposited in small bogs, lakes, or deltas; gradational into other surficial deposits. Thickness locally exceeds 33 feet (10 m)

Qas — **Secondary-stream alluvium (Holocene and upper? Pleistocene)**—Undifferentiated alluvium, colluvium, and alluvial-fan deposits in tributary stream valleys and drainage basins; commonly graded to terraces above level of main stream channels. Locally includes small landslide deposits. Grades into other surficial deposits. Thickness locally more than 16 feet (5 m)

Qf — **Alluvial-fan deposits (Holocene and upper? Pleistocene)**—Unconsolidated, crudely stratified alluvium and colluvium forming well-defined fan-shaped deposits at mouths of tributary valleys. Thickness variable, commonly 33 feet (10 m) or more

Qc — **Colluvium (Holocene and Pleistocene)**—Unconsolidated and unstratified angular debris mantling major stream-valley sides, tributary valleys, and hill slopes; locally includes soil and gravel. Thickness variable, commonly 3 feet (1 m) or more

Qlo — **Loess (Holocene and Pleistocene)**—Poorly consolidated wind-blown silt and fine sand; locally forms dunes a few meters thick

Ql — **Landslide deposits (Holocene and Pleistocene)**—Slumps, landslides, and mudflows of soil and rock. Includes unconsolidated angular rock debris and large slump blocks that have moved or rotated downslope in mass under gravity, commonly as a result of removal of lateral support. Colored on map according to formation involved; landslide scarp shown by hachured symbol. Thickness locally more than 33 feet (10 m)

Qtg — **Terrace deposits and gravel (Holocene and Pleistocene)**—Sand, silt, and unconsolidated boulder, cobble, and pebble gravels occurring in numerous terraces or benches at various levels above present streams. Some terrace levels represent glacial outwash trains graded to moraines; other terrace levels represent redistributed older, higher-level conglomerate and gravel deposits. Thickness variable, usually less than 16 feet (5 m)

Qg — **Gravel (Holocene and Pleistocene)**—Unconsolidated gravel veneer or pavement commonly on pediment surfaces; includes lag concentrate from erosion of nearby formations; commonly forms prominent topographic benches. Thickness variable, locally more than 16 feet (5 m)

Well-rounded clasts from Keetley Volcanics (Oligocene)—As much as 6 inches (15 cm) in diameter; derived from Norwood Tuff (Oligocene and Eocene) west of quadrangle

Well-rounded clasts from Evanston Formation—Quartzite, carbonate, and sandstone clasts recycled from, and having identical range of composition and size as, clasts in conglomerate of Evanston Formation; original source of clasts was Precambrian and Paleozoic rocks in thrust sheets to the west

QTg — **High-level terrace gravel (Pleistocene and Pliocene)**—Boulder and cobble gravels on terraces and pediments more than 246 feet (75 m) above present major stream drainages. The two terraces in northeastern corner of quadrangle south and west of the Green River may be erosional remnants of a high-level terrace, which now extends south from Fort Bridger Airport to the southern part of Evanston quadrangle and is preserved south of the Kemmerer quadrangle. Locally more than 16 feet (5 m) thick

Well-rounded clasts from Evanston Formation—see description above under "**Gravel (Holocene and Pleistocene)**"

Tertiary rocks (Western part and northern Fossil basin)

Tf — **Fowkes Formation (Pliocene and Eocene)**—Generally light-colored, partly tuffaceous mudstone, siltstone, and sandstone; locally contains ostracodal and gastropodal limestone. Not present in eastern part of quadrangle. Thickness ranges from 492 feet (150 m) to as much as 2887 feet (880 m)

Tfg — **Gooseberry Member (Pliocene)**—Indurated conglomerate containing pebbles and cobbles of quartzite, limestone, and volcanic rocks in a white silty matrix (Oriel and Tracey, 1970). Unit may possibly represent northern remnants of middle Tertiary Norwood Tuff. Thickness as much as 197 feet (60 m)

Tfb — **Bulldog Hollow Member (middle Eocene)**—Greenish-gray and green tuffaceous sandstone and siltstone and interbeds of ostracodal and gastropodal limestone; member contains late Bridgerian North American Land Mammal Age (NALMA) mammal fauna (Nelson, 1973). Disseminated biotite and hornblende crystals are characteristic and locally abundant. Oriel and Tracey (1970) reported a K-Ar age on hornblende of 47.7±1.5 million years before present (Ma); recalculation using new constants (Dalrymple, 1979) gives a K-Ar age of 48.9 Ma. Oriel and Tracey (1970) reported a thickness of about 197 feet (60 m) in southwestern part of Sage 15' Quadrangle, but unit may be as much as 2297 feet (700 m) thick farther south

Tfs — **Sillem Member (middle Eocene)**—Pale-pink, buff, and gray, slightly tuffaceous mudstone, claystone, and sandstone containing conglomerate lenses and ostracodal or algal limestone and marlstone interbeds. Basal contact with Wasatch Formation is gradational; thickness reported by Oriel and Tracey (1970) ranges from 98 to 394 feet (30 to 120 m)

Wasatch Formation (middle and lower Eocene and upper Paleocene?)—Red, brown, green, yellow, and gray sequence of mudstone, fluvial sandstone, siltstone, and claystone; subordinate diamictite, conglomerate, grit, marlstone, and pisolitic limestone. Formation varies from east to west across quadrangle. See correlation of map units for members found in eastern and western parts of map area. About 853 feet (260 m) thick in eastern part of quadrangle; as much as 2461 feet (750 m) thick in western part

Tw — **Main body of Wasatch Formation (middle and lower Eocene)**—Variegated but mainly red, interbedded sequence of mudstone, fluvial sandstone, siltstone and claystone, conglomerate, and marlstone. Thickness at least 1476 feet (450 m)

Tw2 — **Upper part (middle and lower Eocene)**—Above angular unconformity developed along western margin of Fossil basin near The Pinnacle; merges with unit Tws to the north and east. About 328 feet (100 m) thick in map area; thickens to the south

Tw1 — **Lower part (lower Eocene)**—Mapped where unconformably overlain by unit Tw along western margin of Fossil basin; not differentiated from unit Tw elsewhere. About 230 feet (70 m) thick where mapped

ls — **Limestone**—Local thin beds of medium-gray limestone. Thickness exaggerated on map

Twt — **Tunp Member (middle and lower Eocene)**—Rubbly, locally derived diamictite in red mudstone matrix. Blocks as much as 18 feet (6 m) in diameter reported by Oriel and Tracey (1970); larger slide blocks may occur. Represents peripheral facies of Wasatch Formation found mainly along northwestern margin of Fossil basin. Thickness locally variable; ranges from 98 to 499 feet (30 to 152 m)

Twb — **Bullpen Member (middle and lower Eocene)**—Variegated red, gray, and green mudstone and gray and tan sandstone containing thin interbeds of granule conglomerate, gray and tan limestone, and light-gray shale; thickness of about 394 feet (120 m) measured at Elk Mountain by Oriel and Tracey (1970)

Twm — **Mudstone tongue (lower Eocene)**—Green and red, brown, and reddish-brown mudstone and shale. Derived from Tunp Member (unit Twt) of Wasatch Formation and lies stratigraphically between Angelo and Fossil Butte Members (units Tga and Tgfb) of Green River Formation in northern part of quadrangle. Pinches out to the east and south. Maximum thickness about 66 feet (20 m)

Twms — **Southern mudstone tongue (lower Eocene)**—Red mudstone, shale, and minor sandstone. Derived from main body of Wasatch Formation (unit Tw) and lies stratigraphically between Angelo and Fossil Butte Members (units Tga and Tgfb) of Green River Formation in southern part of quadrangle. Pinches out to the north and east and merges into unit Tw south of quadrangle. Does not merge with unit Twm to the north. Maximum thickness about 49 feet (15 m)

Twss — **Sandstone unit (lower Eocene)**—Very light-tan to gray sandstone locally present above sandstone tongue (unit Tws) of Wasatch Formation. Maximum thickness about 49 feet (15 m)

Tws — **Sandstone tongue (lower Eocene)**—Tan to brown, medium- to coarse-grained, crossbedded sandstone. Overlies angular unconformity localized along western margin of Fossil basin near The Pinnacle and merges with basal part of unit Tw; pinches out to the north and along east side of basin. Maximum thickness about 82 feet (25 m)

Twgf — **Calcareous member (lower Eocene)**—Light-gray to tan, crossbedded sandstone and shale unit containing light-gray limestone beds 1.6 to 3 feet (0.5 to 1 m) thick, similar to those in Green River Formation. Merges with Fossil Butte Member (unit Tgfb) of Green River Formation to the north and east and merges with lower part of Wasatch Formation (unit Tw) to the south in Evanston 30' x 60' Quadrangle. About 263 feet (80 m) thick along southwestern edge of Fossil basin

Twl — **Lower member (lower Eocene)**—Gray, brown, and red mudstone and sandstone, carbonaceous claystone, and some algal and pisolitic limestone. Locally unconformable with overlying main body. As much as 328 feet (100 m) thick

Twc — **Basal conglomerate member (lower Eocene and upper Paleocene?)**—Conglomeratic sandstone containing clasts from Nugget Sandstone. May include some Paleocene strata (Oriel and Tracey, 1970). Local thickness ranges from about 3 feet (1 m) to 328 feet (100 m) or more

Tg — **Green River Formation (lower Eocene)**—Gray to tan limestone, gray to brown shale, and beds of marlstone, oil shale, and tuff. Formation varies from east to west across map area. See correlation of map units for members found in eastern and western parts of map area. About 574 feet (175 m) thick in eastern part of quadrangle and as much as 525 feet (160 m) thick in western part

Tga — **Angelo Member**—Light-gray to buff, mainly white-weathering siliceous limestone, calcareous shale, and siltstone; includes subordinate tan or laminated limestone, brown algal limestone, marlstone, sandstone, and brown organic shale. Calcareous beds interfinger with sandstone and shale beds of Wasatch Formation to the south and southwest. Maximum thickness about 197 feet (60 m)

Tgfb — **Fossil Butte Member**—Includes light-gray, tan, and buff limestone, calcareous siltstone, marlstone, and shale; and brown, laminated carbonaceous shale and very thinly laminated ("papery") oil shale; tuffaceous interbeds common. Some calcareous beds rich in fossil-fish remains; algal, gastropodal, and ostracodal limestones occur mainly along basin margins between Sillem Ridge and Absaroka thrust fault. Grades into and interfingers with light-gray to buff sandstone and pale-red mudstone beds of Wasatch Formation to the south and southwest. Thickness about 262 to 328 feet (80 to 100 m)

Upper part (Paleocene) of Evanston Formation (Paleocene and Upper Cretaceous)

Te — **Upper unit (upper to middle Paleocene)**—Gray claystone and siltstone containing tan sandstone, carbonaceous claystone, and coal interbeds and a prominent zone of boulder conglomerate beds. Lies with major angular unconformity on pre-Tertiary rocks, including Hams Fork Conglomerate Member of Evanston Formation (unit Keh), along Absaroka thrust; may be disconformable on Hams Fork Member elsewhere. Late to middle Paleocene age based on palynomorphs (D.J. Nichols, written communication, 1980-82; Lamerson, 1982) and vertebrate fauna (Gazin, 1956; Oriel and Tracey, 1970). Locally as much as 984 feet (300 m) thick

Tem — **Main body (upper and middle Paleocene)**—Gray carbonaceous claystone and siltstone and tan sandstone interbeds; gritty and coaly interbeds present locally. Mapped only in Little Muddy Creek area along Absaroka thrust. Age based on palynomorphs (D.J. Nichols, written communication, 1980–82; Lamerson, 1982). Maximum thickness 656 feet (200 m)

Tec — **Conglomerate unit (middle? Paleocene)**—Poorly consolidated boulder and cobble conglomerate containing well-rounded clasts mainly of quartzite; lithologically identical to and probably derived from Hams Fork Conglomerate Member (unit Keh). Mapped only in Little Muddy Creek area along Absaroka thrust. Age indicated by stratigraphic position. Maximum thickness estimated at 164 feet (50 m)

Tel — **Lower unit (middle and upper lower? Paleocene)**—Gray carbonaceous claystone and siltstone; not distinguishable from unit Tem without intervening conglomerate of unit Tec. Mapped only in Little Muddy Creek area along Absaroka thrust. Age based on palynomorphs (D.J. Nichols, written communication, 1980–82; Lamerson, 1982). Maximum thickness about 164 feet (50 m)

Tertiary rocks (Eastern part)

Bridger Formation (middle Eocene)—Light- and medium-gray to greenish-gray mudstone, claystone, siltstone, and sandstone; minor interbeds of light-gray and green tuff; tan to light-gray limestone and marlstone; and thin lignite and coal. Pink or red colors sparsely developed. Only the lower parts (units Tbb and Tba), faunal zones B and A of Matthew (1909), are exposed in quadrangle. Nomenclature follows that of McGrew and Sullivan (1970, p. 68). Boundaries of stratigraphic and biostratigraphic subdivisions have been placed at certain widespread limestone and marlstone interbeds or "white layers" (Sinclair, 1906; Matthew, 1909; Koenig, 1960; Bradley, 1964; and McGrew and Sullivan, 1970). Several widespread limestone layers have been numbered on this map. Middle Eocene age is assigned on the basis of vertebrate fauna and radiometric ages (Mauger, 1977; Berggren and others, 1978). Formation is at least 656 feet (200 m) thick in map area

Tbb — **Bridger B**—Part of "lower Bridger Formation" defined by "G" marker bed of McGrew and Sullivan (1970) (unit Tbg) at base; top not exposed in this quadrangle. Limestone layers mapped in this member are numbered 5 and 4. About 328 feet (100 m) exposed

5 — **5 limestone**—Light- to medium-brown platy limestone, 1 to 3 feet (0.3 to 1 m) thick, locally underlain by brown, slightly calcareous chert. Forms bench and mesa cap in southeastern corner of quadrangle

4 — **4 limestone**—Pale-brownish-gray limestone, 1 to 2 feet (0.3 to 0.6 m) thick, locally platy to splintery, and locally contains brown, yellow-weathering chert. Forms mesa cap east of Church Butte in southeastern part of quadrangle

Tbg — **"G" marker bed of McGrew and Sullivan (1970)**—Widespread light-brown to gray, platy to massive ostracodal limestone. Locally contains algal mounds as much as 3 feet (1 m) high and 13.8 feet (4.6 m) wide. Commonly forms a light-tan caprock on mesas. Thickness 1 to 3 feet (0.3 to 1 m); exaggerated thickness shown on map

Tba — **Bridger A**—Part of "lower Bridger Formation" beneath "G" marker bed; contains layers of white lacustrine limestone numbered here from 3 to 1. Includes Whiskey Butte Bed of Sullivan (1980). Unit split by upper part of Laney Member (unit Tglu) of Green River Formation. About 328 feet (100 m) thick

3 — **3 limestone**—Light-gray to yellowish-brown ostracodal limestone, generally 2 to 3 feet (0.6 to 1 m) thick

2 — **2 limestone**—Dusky-yellow to light-gray, yellow-weathering platy limestone and papery marlstone. Limestone commonly 2 feet (0.6 m) thick, marlstone 4.9 to 10 feet (1.5 to 3 m) thick. Exposed southeast of Opal Bench and east of Chrisman Bench

1 — **1 limestone**—Light-gray platy ostracodal limestone and very light-gray marlstone. Locally contains high-spired gastropod fossils. Forms minor benches generally 3.9 to 4.9 feet (1.2 to 1.5 m) thick

ls — **Limestone**—Unnamed local limestone beds in lower part of unit Tba

Green River Formation (middle and lower Eocene)

Laney Member (middle Eocene)—Tan and brown silty algal limestone and ostracodal marlstone containing thin, light-gray, fine- to coarse-grained sandstone interbeds. Unit split by southward-thinning tongue of Bridger A unit (Tba), which includes Whiskey Butte Bed of Sullivan (1980). As much as 246 feet (75 m) thick

Tglu — **Upper part**—Above Whiskey Butte Bed of Sullivan (1980); equivalent to Cow Hollow Bed of Sullivan (1980). About 33 feet (10 m) thick at Hams Fork River

Tgll — **Lower part**—Below Whiskey Butte Bed of Sullivan (1980); equivalent to Craven Creek Bed of Sullivan (1980). About 115 feet (35 m) thick at Hams Fork River

Tgls — **Limestone interbeds**—Light-gray silty, dolomitic, or marly limestone representing discontinuous lacustrine interbeds in predominantly fluvial Wasatch Formation. Thickness generally less than 3 feet (1 m)

Tgw — **Wilkins Peak Member (middle and lower Eocene)**—Light-gray to tan, silty and sandy, gastropodal, ostracodal, and algal limestone and marlstone; light-tan oil shale; medium- to coarse-grained sandstone; some siltstone and claystone. Termed "middle tongue of Green River Formation" by Oriel (1969). Member divided into two parts north of Hams Fork River. About 197 feet (60 m) thick

Tgwu — **Upper part**—Generally more calcareous than lower part, weathers tan. Thickness as much as 164 feet (50 m), but thins to the south

Tgwl — **Lower part**—Generally less calcareous than upper part, contains oil shale, and weathers light-gray. Thickness as much as 98 feet (30 m), but thins to the north

Tgf — **Fontenelle Tongue (lower Eocene)**—Tan to light-gray gastropodal and ostracodal limestone, laminated tan shale and brown oil shale, and light-gray medium- to coarse-grained sandstone mainly in upper part of unit. As much as 131 feet (40 m) thick; thins and pinches out to the south and west

Tgfs — **Middle part**—Mainly tan shale and brown oil shale. As much as 49 feet (15 m) thick

Tgfl — **Lower part**—Mainly calcareous beds. As much as 49 feet (15 m) thick

Wasatch Formation (middle and lower Eocene)—See description under "**Tertiary rocks (Western part and northern Fossil basin)**"

Twu — **Upper member (middle and lower Eocene)**—Green, gray, brown, and locally red siltstone and fine- to coarse-grained, locally conglomeratic sandstone. Includes Desertion Point tongue of Sullivan (1980). Thickens southward from about 164 feet (50 m) near Hams Fork River to at least 722 feet (220 m) in Evanston 30' x 60' Quadrangle

Twum — **Marker bed (middle and lower Eocene)**—Local marker unit of light-gray sandstone and shale in Twu. About 3 feet (1 m) thick

Twn — **New Fork Tongue (lower Eocene)**—Green mudstone, light-gray marlstone, and light-gray to brown medium- to coarse-grained, locally crossbedded sandstone. About 118 feet (36 m) thick at Slate Creek; thins southward and gradually pinches out south of Little Round Mountain

Twsb — **Sandstone beds (lower Eocene)**—Gray, brown, and red lenticular siltstone and sandstone beds and stringers within units of Green River Formation. Locally as much as 98 feet (30 m) thick

Twlb — **La Barge Member (lower Eocene)**—Red, purple, brown, tan, light-yellow, and variegated and mottled mudstone; tan, gray, and reddish sandstone, locally conglomeratic; a few marlstone and limestone lenses present (Lawrence, 1963, p. 153). La Barge Member has been dated as Lost Cabin NALMA and possibly Lysite, which is not as old as Gray Bull (earliest Wasatchian NALMA) that has been established for beds in Wasatch Formation in Fossil basin area (Oriel and Tracey, 1970; J.G. Honey, written communication, 1984). This difference is depicted in the correlation of map units. Exposed thickness as much as 295 feet (90 m)

Twco — **Basal conglomerate (lower Eocene)**—Brown and red mudstone, sandstone, and cobble conglomerate. Found mainly in Slate Creek area, where most coarse clasts are locally derived. Interfingers with La Barge Member; contacts are gradational. Maximum thickness about 164 feet (50 m)

Twg — **Wasatch and Green River Formations, undivided (middle and lower Eocene)**

Te — **Upper part (Paleocene) of Evanston Formation, undivided (Paleocene and Upper Cretaceous)**—See description under "Tertiary rocks (Western part and northern Fossil basin)"

Mesozoic rocks [Rocks above (west of) Absaroka thrust fault]

Lower part (Upper Cretaceous) of Evanston Formation (Paleocene and Upper Cretaceous)

Keh — **Hams Fork Conglomerate Member (Upper Cretaceous)**—Poorly to moderately consolidated cobble- and boulder-conglomerate beds containing gritty sandstone and siltstone matrix interstratified with sandstone and mudstone beds; clasts of quartzite, chert, and limestone are well rounded and average about 6 inches (15 cm), but range to about 1.5 feet (0.5 m) in diameter. Where exposed, forms conspicuous hogbacks, but is generally poorly exposed; bedding commonly marked by trains of loose boulders. Concordant and folded with underlying Adaville Formation in Lazeart syncline. Palynomorphs (D.J. Nichols, written communication, 1980-82; Lamerson, 1982), leaves, and vertebrate fossils all indicate Late Cretaceous age (Oriel and Tracey, 1970). Thickness about 984 feet (300 m)

Kel — **Lower member (Upper Cretaceous)**—Gray to dark-gray carbonaceous mudstone, siltstone, and sandstone; only present in northern part of quadrangle east of Naughton Reservoir. Thickness about 400 feet (122 m) (Rubey and others, 1975)

Ksj — **Sage Junction Formation (Lower Cretaceous)**—Light-gray siltstone and mudstone containing tan sandstone and quartzite interbeds; thin interbeds of variegated porcellanite are common. Locally contains thin beds of grit and brown to gray fossiliferous limestone. Some coal beds in lower part of unit. Early Cretaceous leaves and invertebrate fauna reported by Rubey (1973). Minimum thickness of 3379 feet (1030 m) in northwestern part of quadrangle

Kc — **Cokeville Formation (Lower Cretaceous)**—Interbedded sequence of dark-gray carbonaceous shaly mudstone and siltstone, tan-weathering sandstone, and highly fossiliferous gray to tan limestone and coquina containing gastropod *(Pyrgulifera)* and pelecypod fauna also characteristic of Bear River Formation (unit Kbr). A few coal beds in upper part. Thickness of 1903 to 2493 feet (580 to 760 m) reported by Rubey (1973) in northwestern part of quadrangle, but thins southward

Ktf — **Thomas Fork Formation (Lower Cretaceous)**—Interbedded pale-red and reddish-brown mudstone and gray, tan, and buff sandstone and gritty sandstone; contains calcareous zones (unit Ktfl). Merges with and is lithologically indistinguishable from upper part of Kelvin Formation (Lower Cretaceous) in northeastern Utah; thickens southward from about 300 feet (100 m) in Sage 15' Quadrangle (Rubey and others, 1975) to at least 1312 feet (400 m) in Evanston 30' x 60' Quadrangle

Ktfl — **Limestone**—Poorly exposed calcareous zones mantled by lavender or gray limestone nodules averaging 0.8 to 1.2 inches (2 to 3 cm) in diameter. About 3 to 7 feet (1 to 2 m) thick

Ks — **Smiths Formation (Lower Cretaceous)**—Mainly light-olive-brown to tan fine-grained sandstone or quartzite, locally containing black carbonaceous shale at the base. Appears to thin southward from 295 to 394 feet (90 to 120 m) in the Sage 15' Quadrangle (Rubey and others, 1975) to 115 to 197 feet (35 to 60 m) in the Evanston 30' x 60' Quadrangle

Kg — **Gannett Group (Lower Cretaceous)**—Brick-red, orange-brown, and maroon mudstone, siltstone, and sandstone; contains a few limestone interbeds in upper part and conglomerate beds in lower part. Thickness as much as 2100 feet (640 m)

Kgl — **Limestone interbeds**—Prominent gray, pink, or lavender nodular limestone interbeds in upper part. Better developed in northern part of area. Beds are about 3 feet (1 m) thick

Kgc — **Conglomerate beds**—Locally thick, chert-pebble conglomerate or grit beds in lower part. Conglomerate more abundant west of Absaroka thrust. Beds are about 3 feet (1 m) thick

Kge — **Ephraim Conglomerate**—Red sandy mudstone, coarse- to fine-grained red to tan crossbedded sandstone, and massive conglomerate containing gray to black chert pebbles. Mapped in western and northwestern part of quadrangle. Thickness as much as 656 feet (200 m)

Jsp — **Stump Formation (Upper and Middle Jurassic) and Preuss Redbeds (Middle Jurassic), undivided**—Contains salt in subsurface in southwestern part of map area near Salt Creek. Estimated thickness 1640 to 1969 feet (500 to 600 m) in western part of Sage 15' Quadrangle

Jt — **Twin Creek Limestone (Middle Jurassic)**—Dark-gray, light-gray to light-yellowish-gray-weathering, thin-bedded limestone and calcareous siltstone containing minor brown mudstone and as much as 98 feet (30 m) of red-weathering limestone breccia, yellow to buff sandstone and siltstone, and red silty mudstone at the base (Rubey and others, 1975). As much as 2887 feet (880 m) thick

JTrn — **Nugget Sandstone (Jurassic? and Triassic?)**—Tan, pink, and white, fine- to medium-grained, well-sorted, medium-bedded to massive, locally crossbedded quartz sandstone, commonly having a dark manganese stain on weathered surfaces. Forms characteristic dark-brown blocky talus slopes. As much as 1476 feet (450 m) thick

Ta — **Ankareh Redbeds (Upper and Lower Triassic)**—Brightly colored interbedded sequence of red and maroon calcareous sandstone or quartzite, siltstone, and mudstone; locally contains minor limestone. Thickness about 738 feet (225 m) (Rubey and others, 1975)

Tt — **Thaynes Limestone (Lower Triassic)**—Predominantly pale-brownish-gray-weathering silty limestone and calcareous siltstone in upper part; greenish-gray, brown-weathering calcareous siltstone, and subordinate silty claystone and limestone predominates in lower part. Thickness ranges from 705 to 1312 feet (215 to 400 m) (Ruby and others, 1975) and increases to the north and west

Tw — **Woodside Redbeds (Lower Triassic)**—Predominantly nonresistant sequence of red siltstone and claystone containing some thin red sandstone and gray limestone interbeds; thickness about 656 feet (200 m)

Td — **Dinwoody Formation (Lower Triassic)**—Greenish-gray thin-bedded calcareous siltstone and silty limestone; estimated thickness 98 to 492 feet (30 to 150 m)

Mesozoic rocks [Rocks below (east of) Absaroka thrust fault]

Lower part (Upper Cretaceous) of Evanston Formation (Paleocene and Upper Cretaceous)

Keh — **Hams Fork Conglomerate Member (Upper Cretaceous)**—See description under "**Mesozoic rocks [Rocks above (west of) Absaroka thrust fault]**"

Kav — **Adaville Formation (Upper Cretaceous)**—Interbedded, mainly nonmarine, gray, brown, and tan shale and siltstone; brown and gray, medium- to fine-grained, locally bioturbated, platy to crossbedded sandstone; carbonaceous shale; numerous coal beds, averaging about15 feet (5 m), but as much as 115 feet (35 m) thick. Early Campanian age is indicated by palynomorphs (D.J. Nichols, written communication, 1980-82; Lamerson, 1982). Thickness of unit about 2034 feet (620 m)

Kal — **Lazeart Sandstone Member**—Very light-gray, yellow-brown, and tan, fine- to medium-grained "salt and pepper" sandstone forming thick cliffs; brownish-gray shale and coal beds in slopes between sandstone cliffs. Sandstone units contain marine fossils and bedding indicative of progradational beach sequences that overlap southward. About 591 feet (180 m) thick in south; thins markedly and locally pinches out north of Hams Fork River

Kh — **Hilliard Shale (Upper Cretaceous)**—Dark-olive-gray marine shale, siltstone, and sandy shale containing thin, tan to light-gray sandstone and limestone interbeds, particularly in upper part. Palynomorphs (D.J. Nichols, written communication, 1980-82; Lamerson, 1982) indicate Santonian and Coniacian age. Poorly exposed; estimated minimum thickness 5906 feet (1800 m)

Khh — **Hinshaw Member of Smith (1965)**—Upper part of Hilliard Shale consisting of interbedded marine shale and sandstone units 1 to 33 feet (0.3 to 10 m) thick; a transitional sequence from shales of main body of Hilliard Shale into overlying Lazeart Sandstone Member of Adaville Formation. Sandstone units are gray to tan, fine-grained, somewhat speckled with feldspar and chert grains, and locally burrowed. Sedimentary structures in sandstone include hummocky bedding, large-scale ball and pillow structures, some trough cross-stratification; bedding vague, mainly 0.7 to 1.6 feet (0.2 to 0.5 m) thick. Sandstone units have sharp basal contacts. Overall thickness of member approximately 853 to 1001 feet (260 to 305 m)

Khs — **Shurtleff Sandstone Member**—Ledge-forming gray to buff, fine-grained to gritty sandstone containing abundant oyster shells in middle part of Hilliard Shale. In northern part of quadrangle, member is about 984 feet (300 m) thick. Intertongues with main body of Hilliard Shale and pinches out southwest of Frontier

Khc — **Conglomerate of Little Muddy Creek of Royse and others (1975)**—Coarse boulder conglomerate and sandstone that grade abruptly upward and downward and intertongue laterally with typical Hilliard Shale. Contains well-rounded boulders as much as 7 feet (2 m) in diameter of Mesozoic and Paleozoic rocks now exposed in upper plate of Absaroka thrust; vertical succession in clast composition represents inverted succession of source beds according to Royse and others (1975). Sparse palynomorphs (D.J. Nichols, written communication, 1980-82; Lamerson, 1982) indicate a Santonian and Coniacian age. Maximum thickness about 2001 feet (610 m)

Kf — **Frontier Formation (Upper Cretaceous)**—Interbedded marine and nonmarine sequence of sandstone, siltstone, and carbonaceous shale containing interbeds of coal and, locally, porcellanite and conglomerate. Palynomorphs (D.J. Nichols, written communication, 1980-82; Lamerson, 1982) and molluscan fauna (Merewether and others, 1984; Cobban and Reeside, 1952; Cobban and Kennedy, 1989; M'Gonigle, 1982) indicate early Coniacian to Cenomanian age. Mapped in Little Muddy Creek area. Maximum thickness about 2198 feet (670 m)

Kfd — **Dry Hollow Member of Hale (1960)**—Gray, greenish-gray, and tan nonmarine shale and siltstone containing tan and brown, fine- to medium-grained, platy to crossbedded, locally bioturbated thin sandstone interbeds, and coal. Uppermost sandstone unit, which commonly is more than 10 feet (3 m) thick, contains marine fauna in upper part and is directly underlain by the Kemmerer coal zone. Early Coniacian to late Turonian age based on palynomorphs (D.J. Nichols, written communication, 1980-82; Lamerson, 1982). About 328 to 427 feet (100 to 130 m) thick

Kfdc — **Conglomerate**—Pebble conglomerate locally developed in lower part of Dry Hollow Member; locally forms channels cutting into Oyster Ridge Sandstone Member. About 3 to 10 feet (1 to 3 m) thick

Kfo — **Oyster Ridge Sandstone Member**—Predominantly light-tan to white, fine- to medium-grained, parallel-bedded to crossbedded, cliff-forming sandstone containing some brown shale layers. Sandstone units show bedding and fauna indicative of marine shoreline deposition; minor channeling in upper parts. About 49 to 197 feet (15 to 60 m) thick

Kfa — **Allen Hollow Member of Hale (1960)**—Dark-gray to greenish-brown marine shale; sandstone and siltstone beds in upper part. Middle Turonian age based on *Collignoniceras woolgari* fauna (Hale, 1960). Largely covered; about 302 feet (92 m) thick

Kfc — **Coalville Member of Hale (1960)**—Dark-greenish-gray shale and tan, fine-grained, flaggy to crossbedded and ripple-marked, bioturbated sandstone. Contains brackish-water to marine fauna of early Turonian age. Thickness about 79 to 151 feet (24 to 46 m)

Kfcc — **Chalk Creek Member of Hale (1960)**—Gray, greenish-gray, and brown, largely nonmarine shale, bentonitic shale, tuff and tuffaceous sandstone, carbonaceous shale; coal; and tan, fine- to coarse-grained, platy to crossbedded, locally bioturbated sandstone. Basal part interfingers with Aspen Formation (unit Ka) near Cumberland Gap; Cenomanian age based on molluscan fauna and stratigraphic position (M'Gonigle, 1982; Cobban and Kennedy, 1989). Thickness about 984 to 1411 feet (300 to 430 m)

Ka — **Aspen Formation (Upper and Lower Cretaceous)**—Dark- and light-gray, silvery-weathering marine shale, siltstone, siliceous sandstone, and porcellanite; porcellanite beds form prominent gray ridges. Contains fish scales; palynomorphs and molluscan fauna (Cobban and Reeside, 1952; Cobban and Kennedy, 1989) indicate Cenomanian and Albian age. About 804 to 1214 feet (245 to 370 m) thick

Kbr — **Bear River Formation (Lower Cretaceous)**—Dark-gray carbonaceous shale, fine-grained tan to olive-tan sandstone, and very fossiliferous limestone with characteristic gastropod *(Pyrgulifera)* and pelecypod fauna. Poorly exposed; commonly forms slopes mantled with gastropod and pelecypod shells. Palynomorphs (D.J. Nichols, written communication, 1980-82; Lamerson, 1982) and shelly fauna indicate Albian age. Estimated to be 656 to 1312 feet (200 to 400 m) thick

Kg — **Gannet Group (Lower Cretaceous)**—Brick-red, orange-brown, and maroon mudstone, siltstone, and sandstone; contains a few gray, pink, or lavender nodular limestone interbeds in middle and upper part and locally a few chert-pebble-conglomerate beds in lower part. Limestone better developed in northern part of map area. Thickness about 656 feet (200 m)

Js — **Stump Formation (Upper and Middle Jurassic)**—Greenish-gray glauconitic sandstone, siltstone, and limestone. Thickness 98 to 164 feet (30 to 50 m)

Jp — **Preuss Redbeds (Middle Jurassic)**—Thinly interbedded, dark-reddish-brown to purplish-red siltstone, mudstone, and sandstone. Thickness estimated at 394 feet (120 m) in eastern part of quadrangle

Jt — **Twin Creek Limestone (Middle Jurassic)**—See description under "**Mesozoic rocks [Rocks above (west of) Absaroka thrust fault]**." About 787 to 984 feet (240 to 300 m) thick

JTrn — **Nugget Sandstone (Jurassic? and Triassic?)**—See description under "**Mesozoic rocks [Rocks above (west of) Absaroka thrust fault]**." About 656 feet (200 m) thick

Paleozoic rocks [Above (west of) Absaroka thrust fault only]

Pp — **Phosphoria Formation (Lower Permian)**—Dark-gray siltstone, thin-bedded black chert and limestone, and a few thin beds of phosphate rock. Resistant ledges of gray cherty dolomitic limestone and bedded chert in upper part; nonresistant dark phosphatic siltstone, gray dolostone, and dark cherty siltstone. Several beds of phosphate rock and vanadium-bearing carbonaceous siltstone in lower part of unit. Thickness about 427 feet (130 m) (Rubey and others, 1975)

PPw — **Wells Formation (Lower Permian and Upper and Middle Pennsylvanian)**—Interbedded quartzite, siltstone, and limestone or dolostone in upper part; mainly white to buff, fine-grained, well-sorted quartzite and sandstone in lower part. Thickness ranges from 607 to 1001 feet (185 to 305 m) (Rubey and others, 1975)

Pwl — **Limestone (Lower Permian)**—Gray limestone in upper part of Wells Formation; mapped separately only in Sage and Kemmerer 15' quadrangles by Rubey and others (1975). Thickness about 230 feet (70 m)

PPMa — **Amsden Formation (Pennsylvanian and Upper Mississippian)**—Interbedded gray, red, black, or brown, cherty limestone and limestone breccia, buff sandstone and quartzite, and variegated red, yellow, and green siltstone and claystone. Thickness ranges from 148 feet (45 m) in western part of area to 394 feet (120 m) in eastern part (Ruby and others, 1975)

MDd — **Darby Formation (Lower Mississippian and Upper Devonian)**—Dark-gray fetid dolostone and gray dolostone containing interbeds of variegated black, yellow, and red calcareous siltstone. Thickness about 886 feet (270 m)

Ob — **Bighorn Dolomite (Upper Ordovician)**—Resistant, mottled light- to dark-gray massive dolostone. Thickness about 607 feet (185 m) in southwestern corner of Sage 15' Quadrangle

Cg — **Gallatin Limestone (Upper Cambrian)**—Mottled yellow and tan, thin-bedded to massive dolostone and limestone. About 230 feet (70 m) exposed in incomplete section in southwestern corner of Sage 15' Quadrangle