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Age	Unit Name (Symbol)	Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
LOWER CRETACEOUS	Kootenai Formation (Kk)	Reddish-brown, olive-gray, and dusky-purple bentonitic mudstone interbedded with lenticular, fine- to coarse-grained sandstone. Thin zones of light-gray nodular limestone common in upper part. Greybull Sandstone Member (thick, lenticular, fine-grained sandstone) locally present at top. Pryor Conglomerate Member at base is brown conglomerate and pebbly coarse-grained sandstone, 6 m (20 ft) to 18 m (60 ft) thick. Total thickness 59 m (195 ft) to 75 m (245 ft).	Mass Wasting—Landslides and slumps common. Mineral Resources—Bentonite.	Structural and Tectonic Features and Processes—Exposed in massive anticline. Pryor Conglomerate Member forms hogbacks.	Deposited in Cretaceous Interior Seaway. Equivalent to Clovery Formation (Wyoming terminology).
LOWER CRETACEOUS AND UPPER JURASSIC	Cloverly Formation and Morrison Formation, undivided (KJcm)	Cloverly Formation: "Rusty beds" with thin ironstone beds, sandstone, and dark-gray shale overlying lenticular channel sandstones of the Greybull Sandstone Member in the upper 49 m (160 ft). Remainder is varicolored shale and gray sandstone not easily separated from underlying Morrison Formation. Morrison Formation: Pale green and varicolored shale, mudstone, and white, lenticular, ledge-forming sandstone beds, locally cross-bedded. Combined thickness 189 m (620 ft).	Mass Wasting—Shale may cause erosion and mass movement. Sandstone beds in Morrison Formation form resistant ledges. Mineral Resources—Clay and shale. Coal. Moderate oil and gas potential.	None documented in GRI report.	Cloverly Formation named from Cloverly Post Office on eastern side of the Bighorn Basin. Nonmarine setting.
UPPER JURASSIC	Morrison Formation (Jm)	Variegated, mainly greenish-gray and pale reddish-brown mudstone. Very fine to fine-grained, quartzose, calcareous, cross-bedded sandstones are commonly present at about midsection, 1.5 m (5 ft) to 3 m (10 ft) thick but locally can be as much as 9 m (30 ft) thick. Total thickness 91 m (300 ft) to 107 m (350 ft).	Mineral Resources—Low oil and gas potential.	Paleontological Resources—Contains fragmentary dinosaur bones in the nonmarine sediments (Santucci et al. 1999). *Allosaurus* remains were discovered in the Morrison Formation on Bureau of Land Management property about 32 km (20 mi) south of the national recreation area (Santucci et al. 1999). A sauropod track locality was identified on the west side of Sykes Mountain in the upper portion of the Salt Wash Member (Engelmann and Hasiotis 1999). Contains tetrapod swim tracks (Harris and Lacovara 2004; Mickelson 2005). Turner et al. (2004) reconstructed the ancient ecosystem of the Morrison Formation. Structural and Tectonic Features and Processes—Exposed in massive anticline.	Perhaps the most well-known dinosaur-bearing formation in the western United States. Upper contact at the base of the Pryor Conglomerate Member of the **Kootenai Formation (Kk)**. Basal contact at the top of fossiliferous limy sandstone and coquina of the underlying **Swift Formation (Jes)**. Marine, freshwater, and terrestrial settings.
	Swift Formation (Jes)	Greenish-gray to yellowish-gray fine- to coarse-grained, plane-bedded or cross-bedded, glauconitic, fossiliferous sandstone or very sandy limestone coquina at the top. Medium-gray poorly resistant claystone interbedded with silty to sandy moderately resistant, greenish-gray claystone in the lower part. Greenish-gray to yellowish-gray, poorly resistant, glauconitic, fossiliferous sandstone at the base and one or more similar thin glauconitic sandstones higher in the unit. Thickness about 35 m (115 ft).	Mass Wasting—Poorly to moderately resistant to erosion. Forms resistant ledges and hogbacks. Mineral Resources—Low oil and gas potential.	Paleontological Resources—Coquina. Structural and Tectonic Features and Processes—Exposed in massive anticline.	Upper formation of **Ellis Group**. Marine depositional setting.
	Rierdon Formation (Jer)	Light-gray limestone, brownish-gray, sandy oolitic limestone, and light yellowish-gray, fine-grained calcareous sandstone. Greenish-gray to light-brown calcareous shale in lower part. Thickness about 55 m (180 ft).	Mass Wasting—Shale may cause erosion and mass movement. Sandstone forms resistant ridge; limestone forms smooth slopes. Mineral Resources—Building stone (oolitic limestone).	Structural and Tectonic Features and Processes—Exposed in massive anticline.	Middle formation of **Ellis Group**. Marine depositional setting.
	Sundance Formation (Js)	Gray-green sandstone, siltstone, and shale with thin fossiliferous limestone. Resistant glauconitic, cross-bedded sandstone at top. Thickness about 113 m (370 ft).	Mass Wasting—Top (sandstone) resistant to erosion. Shale may cause erosion and mass movement.	Paleontological Resources—Cephalopods (*Belemnites* sp.), bivalves (*Gryphaea* sp.), and star-shaped crinoid columnals (*Pentacrinus* sp.) (Richards, 1955). In the Crooked Creek area, the Rierdon Formation (part of Sundance Formation of Wyoming terminology) contains fossil fish (David Lopez, geologist/independent consultant, written communication, January 31, 2011).	Extensive, covering parts of Montana, Wyoming, Colorado, and South Dakota. Largely marine with abundant fauna.

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Age	Unit Name (Symbol)	Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
UPPER AND MIDDLE JURASSIC	Sundance Formation and Gypsum Spring Formation, undivided (Jsg)	Sundance Formation (Upper and Middle Jurassic): Green and gray shale, greenish-gray, glauconitic, limy sandstone, and thin beds of gray, fossiliferous limestone. Thickness 110 m (360 ft) to 140 m (374 ft). Gypsum Spring Formation (Middle Jurassic): Red and gray shale, fossiliferous limestone, and gypsum. Gypsum bed at base up to 30 m (98 ft) thick. Total thickness 20 m (65 ft) to 70 m (230 ft).	Mass Wasting—Poorly to moderately resistant to erosion. Mineral Resources—Gypsum.	Caves and Karst—Dissolution possible in gypsum beds. Paleontological Resources—See individual unit descriptions.	See individual unit descriptions.
MIDDLE JURASSIC	Gypsum Spring Formation (Jgs)	Red-brown silty shale with interbedded gypsum, limestone, and dolomite. Thickness about 61 m (200 ft).	Mass Wasting—Poorly consolidated and readily eroded. Mineral Resources—Massive, white gypsum bed at base.	Caves and Karst—Dissolution possible in gypsum beds.	Occurs in Yellowstone province, Snake River basin, Greater Green River basin, Wasatch uplift, Uinta basin, and Uinta uplift. Represents basal deposits of transgressive sea.
	Piper Formation (Jep)	Upper part: Brownish-red claystone, with scattered streaks of green claystone interbedded with brownish-red siltstone. Middle part: White dolomitic limestone bed and gray-to-lavender chalcedony nodules. Medium-gray limestone and white dolomitic limestone interbedded with red claystone and white gypsum. Lower part: Dark brownish-red claystone, with lenses of white gypsum underlain by massive white gypsum, interbedded with some brownish-red claystone, siltstone, and medium-gray limestone. Thickness 23 m (75 ft) to 46 m (150 ft).	Mass Wasting—Forms resistant ledge below smooth slopes of the **Rierdon shales (Jer)**. Mineral Resources—Gypsum. Chalcedony nodules.	Caves and Karst—Dissolution possible in gypsum beds. Structural and Tectonic Features and Processes—Exposed in massive anticline.	Includes distinctive "red beds." Named for town of Piper, Montana. Lower formation of **Ellis Group**. Marine depositional setting.
JURASSIC	Ellis Group, undivided (Je)	Consists of the **Swift Formation (Jes)**, **Rierdon Formation (Jer)**, and **Piper Formation (Jep)**. See descriptions of individual units.	Mass Wasting—Poorly to moderately resistant to erosion. **Swift Formation (Jes)** forms ledges. Mineral Resources—Oil and gas. Gypsum.	Structural and Tectonic Features and Processes—Forms hogbacks. Part of Montana folded belt province.	Marine depositional setting. Equivalent to Sundance Formation of Wyoming terminology.
TRIASSIC	Chugwater Formation (TRc)	Interbedded moderate reddish-brown, fine-grained sandstone, siltstone, and mudstone. Thin light-gray limestone bed is present near the top. Rioux (1994) noted thin sandstone beds near the top and dolomite lenses. Gypsum beds are common in lower part. Typically, strike valleys develop at the base of the Chugwater Formation above resistant rocks of the **Phosphoria (Pp)** and **Tensleep (PNt)** formations. Thickness 137 m (450 ft) to 250 m (820 ft).	Mass Wasting—Poorly to moderately resistant to erosion. Parent material for highly erodible soils. Mineral Resources—Gypsum thickens to about 3 m (10 ft) locally.	Seeps and Springs—Produces groundwater high in sulfates (attributed to gypsum). Hosts springs. Paleontological Resources—The only fossils from this unit occur in the gray chert pebbles within the basal conglomerate, which Richards (1955) reported as Pennsylvanian fauna eroded from the **Tensleep Formation (PNt)** or **Amsden Formation (PNMa)**. Structural and Tectonic Features and Processes—Exposed in massive anticline.	Very scenic, brick-red color. Deposited across the shoreline zone of a shallow coastal shelf.
LOWER TRIASSIC AND PERMIAN	Chugwater Formation and Goose Egg Formation, undivided (TRPcg)	Chugwater Formation: Red to dark reddish-brown, generally thin-bedded, locally cross-bedded, calcareous or gypsiferous, fine-grained and very fine-grained sandstone and siltstone. Goose Egg Formation: Light-gray, very light-gray or pink, finely crystalline gypsum, interbedded with red, fine-grained sandstone and siltstone. Occurs only locally. Combined thickness about 150 m (492 ft).	Mass Wasting—Potential for erosion. Mineral Resources—Gypsum.	Caves and Karst—Dissolution possible in gypsum beds. Structural and Tectonic Features and Processes—Exposed in massive anticline.	Prominent, resistant 1.5-m- (5-ft-) thick, light-gray limestone ledge about 35 m (115 ft) below the top of the **Chugwater Formation (TRc)**.
	Goose Egg Formation (TRPg)	Upper unit: Greenish-gray shale, some dolomite and gypsum. Thickness 15 m (50 ft). Middle unit: Gray, resistant cherty dolomitic limestone and dolomite. Thickness 27 m (90 ft). Lower unit: Mostly red shale with some gypsum, dolomite; thin phosphorite and blue gray chert at top, probably equivalent to the **Phosphoria Formation (Pp)** to the west. Thickness 40 m (130 ft). Total thickness about 82 m (270 ft). Pierce (1997) described the formation as follows: Red sandstone and siltstone, white gypsum, and a few thin beds of dolomite. Thickness about 50 m (164 ft).	Mass Wasting—Shale may cause erosion and mass movement. Mineral Resources—Gypsum. Phosphorite.	Caves and Karst—Dissolution possible in gypsum beds.	Deposited in a shallow lagoon or tidal flat adjacent to the Phosphoria sea. The hematitic rocks suggest marginal marine, high humidity, and warm arid climate. Chemically deposited rocks suggest submergence of detrital source area or increased evaporation rate.

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Age	Unit Name (Symbol)	Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
PERMIAN	Phosphoria Formation (Pp)	Light-gray limestone, sandstone and quartzite, commonly grayish-pink, cherty. Lopez (2000) noted that because the formation is a very thin remnant, it was mapped separately only where scale allowed, but otherwise included with the **Tensleep Formation (PNt)**. Thickness 3 m (10 ft) to 15 m (50 ft).	Mineral Resources—Radioactive layers (uranium). Locally, a reddish-brown variety of chert, known as Dryhead Agate, mined and collected for lapidary purposes. Phosphorite. Hydrocarbon source rock.	None documented in GRI report.	Cyclic marine deposit (upwelling and geothermal conditions).
PENNSYLVANIAN	Tensleep Sandstone (PNt)	Very light-brown to light yellowish-brown, very fine-grained to medium-grained, well-sorted, well-rounded, cross-bedded, porous-to-tightly cemented sandstone. Locally, contains some thin limestone beds, nodular chert, dolomite, or silty green shale. Also, locally silicified to form quartzite (Lopez 2000). Thickness up to 61 m (200 ft).	Mass Wasting—Shale may cause erosion and mass movement. Mineral Resources—High oil and gas potential. Nodular chert.	Seeps and Springs—Source of groundwater. Hosts springs. Paleontological Resources—Foraminifera (*Bradyina* sp.) and fusulinids (*Climacammina* sp., *Fusulina rockymontana*, *Pseudostaffella* sp., *Wedekindellina euthysepta*, and *W. excentrica*) (Richards 1955). Structural and Tectonic Features and Processes—Exposed in massive anticline.	Named for extensive exposures in walls of lower canyon of Tensleep Creek in Bighorn and Powder River basins, Big Horn County, Wyoming. Extends along flanks of Bighorn Range. Marine and shoreline setting.
UPPER AND MIDDLE PENNSYLVANIAN, MIDDLE PENNSYLVANIAN TO UPPER MISSISSIPPIAN	Amsden Formation and Tensleep Sandstone, undivided (PNMat)	Tensleep Sandstone (Upper and Middle Pennsylvanian): Light-gray, well-sorted, cross-bedded and massive sandstone. Thin beds of gray limestone and dolomite in lower part. Thickness 40 m (131 ft) to 75 m (246 ft). Amsden Formation (Middle Pennsylvanian to Upper Mississippian): Red shale contains some gray, dolomitic limestone and chert and hematite nodules. Basal part commonly red siltstone or sandstone. Thickness 45 m (147 ft) to 90 m (295 ft).	Mass Wasting—Shale may cause erosion and mass movement. Mineral Resources—Uranium. Oil and gas. Chert and hematite nodules.	See individual unit descriptions.	See individual unit descriptions.
LOWER PENNSYLVANIAN AND UPPER MISSISSIPPIAN	Amsden Formation (PNMa)	Light-red to red, purple, green, or light-brown shale, siltstone, and sandstone, interbedded with very light-gray to gray limestone and dolomite that locally contains chert. Lopez (2000) also included mudstone in description. Thickness ranges from 43 m (140 ft) to 91 m (300 ft). Locally, tectonically thinned to only a few feet along the margins of Pryor Mountains uplift (Lopez 2000).	Mass Wasting—Shale may cause erosion and mass movement. Mineral Resources—Uranium. Low oil and gas potential.	Paleokarst—Unconformably overlies karst surface developed on limestone of the **Madison Group (Mm)**. Paleontological Resources—Marine invertebrates, including sponge spicules, fusulinids (*Climacammina* sp., *Pseudostaffella* sp., and *Profusulinella* sp.), and foraminifera (*Calcitornellids*, *Bradyina* sp., and *Tetrataxis* sp.) (Richards 1955).	Represents widespread Kaskaskia paleokarst surface. Characteristically produces pink staining on underlying cliffs of **Madison Group (Mm)**. Deposited in a transgressive sea.
MIDDLE MISSISSIPPIAN	Madison Group, undivided (Mm)	Light-gray to light brownish-gray limestone and dolomitic limestone. Thick-bedded to massive in the upper part (Mission Canyon Limestone) and thin-bedded to thick-bedded in the lower part (Lodgepole Limestone). Also contains thin, interbedded gray shales. Locally, at base, is Cottonwood Canyon Member (Lower Mississippian and Upper Devonian), which consists of gray dolomite, dolomitic siltstone, and sandstone about 5 m (16 ft) thick. Total thickness 149 m (490 ft) to 305 m (1,000 ft).	Mass Wasting—Shale may cause erosion and mass movement. Mineral Resources—Upper massive beds of very pure limestone are quarried in the southwest part of the Pryor Mountains for industrial uses and lime production. Oil and gas potential; geologic and production zones A–D developed by oil exploration (McCaleb and Wayhan 1969). Collapse features may host low-grade uranium deposits.	Seeps and Springs—Major water-bearing unit in the region. Hosts springs. Caves and Karst—Fractures. Collapse features and caves are common at the upper karst surface, which is infilled with shale from the overlying **Amsden Formation (PNMa)**. Provides evidence of past cave formation and hosts present-day caves. Caves within Madison Group may preserve Quaternary fossils. Paleontological Resources—Highly fossiliferous formation within the national recreation area. Produces abundant marine invertebrates, including bryozoans, corals, brachiopods, and crinoids (Santucci et al. 1999). Crushing teeth of the cochliodont (fish) *Hybodus* also occur.	Historical lime production at Lime Kiln Creek along the Ok-A-Beh road. Forms the walls of Bighorn Canyon. Widespread across Idaho, Montana, North Dakota, South Dakota, and Wyoming. Marine depositional setting.