Map Unit Properties Table: Fossil Butte National Monument

Colored rows indicate units mapped within Fossil Butte National Monument. Italicized text refers to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
QUATERNARY (Holocene)	Strip Mine (Qsm)	Strip coal mine operating today. Located southeast of the monument.	*Exploration and Development of Energy Resources*: Surface mining of coal. Not mapped within the monument.	Coal.	*Shaping the Modern Landscape:* Mines are modern anthropogenic alterations to the landscape. *The Great Compression:* Local coal is Cretaceous in age (primarily **Kav**) and represents lush coastal forests near the Cretaceous Interior Seaway.
	Quarry (Qu)	Operating or abandoned quarry site for the purpose of excavating fossil fish and other fossils from the Green River Formation. Not mapped within the monument because the areal extents of quarries are too limited to be mapped at 1:24,000 scale.	*Paleontological Resource Management:* Monument staff collaborates with outside quarries to document significant fossil discoveries. *Mass Wasting:* Quarry walls may be subject to rockfall.	*Eocene Paleontological Resources:* Fossils are quarried primarily from the Green River Formation.	*Shaping the Modern Landscape:* Quarries are modern anthropogenic alterations to the landscape. *The Global Greenhouse and Great Lakes of Wyoming:* Each year, tens- to hundreds-of-thousands of Eocene fossils, primarily fish, are excavated from Fossil Basin quarries.
QUATERNARY (Holocene and Pleistocene)	Alluvium (Qal)	Unconsolidated gravel, sand, silt and channel flood-plain deposits along present main streams; includes channel fill and flood plain deposits, alluvial fan and terrace deposits.	May be inundated by rare flood events. Mapped along the southernmost border of the monument.	*Quaternary Paleontological Resources:* Bison bones. Alluvial fans, channel fill, flood-plain, and terrace deposits.	*Shaping the Modern Landscape:* Product of fluvial processes.
	Secondary-stream alluvium (Qas)	Unconsolidated alluvium, colluvium, and alluvial fan deposits in tributary stream valleys.	*Disturbed Lands:* Although not a primary issue, the abandoned road and culvert in Smallpox Creek may increase gully development. May be inundated by rare flood events.	*Quaternary Paleontological Resources:* Bison bones. Alluvium, colluvium, and alluvial fan deposits in tributary stream valleys.	
	Colluvium (Qc)	Unconsolidated debris.	Not mapped within the monument.	Debris covers stream and tributary valley sides and hill slopes.	*Shaping the Modern Landscape:* Results from erosion processes.
	Landslide deposits (Qls)	Large hummocky slumps, landslides, and mudflows of unconsolidated rock debris, soil, and slump blocks. Form mainly within the Wasatch Formation (**Tw**).	*Mass Wasting:* Unstable slopes may fail. Individual landslides are mapped within the monument, but to the north, landslides are too numerous to map individually.	*Quaternary Paleontological Resources:* Bison bones may potentially be discovered in **Qls**.	*Shaping the Modern Landscape:* If present, the overlying Green River Formation collapses, slides, or moves when **Tw** is compromised.
	Terrace deposits (Qtg)	Unconsolidated boulders, cobbles, pebble gravels, sand and silt.	Not mapped within the monument.	Occur in terraces above present streams.	*Shaping the Modern Landscape:* Some **Qtg** are interpreted as glacial outwash deposits from glacial moraines in the Uinta Mountains; other **Qtg** are composed of redistributed older conglomerate.
	Younger terrace deposits (Qty)			Occur in terraces that are younger and topographically lower than older terrace deposits (not mapped in the vicinity).	
	Talus and rubbly slope deposits (Qd)	Unconsolidated angular rock debris.	*Mass Wasting:* Results from mass-wasting processes. Potential for further movement.	Talus blocks.	*Shaping the Modern Landscape:* Product of mass-wasting processes.
	Loess (Ql)	Unconsolidated fine sand and silt.	Not mapped within the monument.	Well-sorted silt.	*Shaping the Modern Landscape:* Deposited by wind.
	Gravel (Qg)	Unconsolidated gravel, pebbles, sand and silt exposed in the southwestern corner of the monument.	*Disturbed Lands:* Gully development along Smallpox Creek may threaten a rare stand of *Lepidium integrifolium* var. *integrifolium* (entire-leaved peppergrass).	Found on pediment surfaces and includes lag concentrates from nearby older formations.	*Shaping the Modern Landscape:* Product of erosion.
PALEOGENE-NEOGENE (Oligocene-Pliocene)	Unconformity				

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Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
PALEOGENE / Eocene	Fowkes Formation: Sillem Member (Tfs)	Gray, pale-pink siltstone, sandstone, and tuffaceous mudstone with lenses of conglomerate and interbeds of marlstone, ostracodal limestone, and stromatolitic limestone. Preserved in isolated, erosional remnants in the western part of Fossil Basin. 30–120 m (100–390 ft) thick.	Not mapped within the monument.	Gradational with the underlying Wasatch Formation.	*The Global Greenhouse and Great Lakes of Wyoming:* The youngest consolidated formation in Fossil Basin, the Fowkes Formation is an alluvial deposit, similar to **Tw**.
Green River Formation	Green River Formation undifferentiated (Tgr)	Buff to brown, kerogen-rich laminated micrite (fine-grained limestone), gray to tan limestone, marlstone, and tuff beds. Light-brown to gray sandstone, siltstone, and gray to green mudstones become abundant toward the basin margins; 100–250 m (330–820 ft) thick; thins toward the west.	Not mapped within the monument. Within the monument, the Green River Formation is divided into the three members listed below. See descriptions of geologic issues for individual members.	*Eocene Paleontological Resources:* Abundant fossils. See members below and Table 1.	*The Global Greenhouse and Great Lakes of Wyoming:* Represents deposits of Fossil Lake.
	Angelo Member (Tga)	White, buff, and brown dolomite and silty dolomicrite. Quartz and feldspar form a high percentage of most dolomicrite beds. Tufa coated sticks and logs mark the contact with **Tgfb**. Grades margin-ward into **Tw**. Up to 40 m (130 ft) thick.	*Paleontological Resource Management:* Documentation, inventory, monitoring, and protection. *Mass Wasting:* Forms steep slopes in the northern half of Fossil Basin, including the slopes that cap Fossil Butte. Potential rockfall and cliff collapse.	*Eocene Paleontological Resources:* Ostracods, plant fragments, bird bones in one limestone unit; bird tracks in one sandstone unit; stromatolites and caddisfly larval cases; avian egg-shell fragments. Fossil fish are mostly absent except in a few laminated micrite beds. *Stratigraphic Features:* Calcite psuedomorphs after saline minerals; salt casts; tufa; desiccation cracks.	*The Global Greenhouse and Great Lakes of Wyoming:* Represents the culminating, underfilled stage of Fossil Lake between 51.3 million and 45.1 million years ago.
	Fossil Butte Member (Tgfb)	Buff to brown kerogen-rich laminated micrite, gray to tan limestone (micritic, gastropodal, ostracodal), gray to brown laminated micrite, marlstone, and abundant tuff beds. Buff to gray-green siltstone and mudstone become abundant toward the basin margins. Contact with **Tga** is marked by an ochre tuff bed that is 3–4 m (10–13 ft) above the "kspar tuff." Contact with **Tgrh** is marked by the "lower oil shale" 1–2 m (3–7 ft) below the "lower sandwich bed" (see text). In central and southern Fossil Basin, the lower contact is the top of **Tws**. Thickness is 70 m (230 ft) at Fossil Butte; thins toward the west and grades into and interfingers with **Tw** toward the basin margins.	*Paleontological Resource Management:* Documentation, inventory, monitoring, and protection. Monument's research and interpretation quarry is located in **Tgfb**. Historic quarries are also in this unit. Potential fossil theft. *Energy Resource Exploration and Development:* Areas east and west of the monument that contain "oil shale" (kerogen-rich laminated micrite) may be leased for future development. *Mass Wasting:* Forms cliffs and bluff exposures at Fossil Butte. Potential rockfall or cliff collapse.	*Eocene Paleontological Resources:* Two groups of fossil localities: nearshore and deep-water. Deep-water sites include the "18-inch layer," which includes Fossil Butte. As of this report, fossils in **Tgfb** include 23 genera of fish, 19 genera of amphibians and reptiles, 26 genera of mammals, 14 genera of birds, 23 genera of invertebrates, 30 genera of insects, and 103 genera of plants (table 1). *Stratigraphic Features:* Predominantly kerogen-rich laminated micrite; burrows.	*The Global Greenhouse and Great Lakes of Wyoming:* Represents the balanced-fill phase of Fossil Lake between 52.0 million and 51.3 million years ago. As with the other two members, the lateral changes in rock type reflect the transition from lake-margin to lake-central depositional environments (see text). About 200–500 fossils are collected annually from the research and interpretation quarry within the monument. The Haddenham and Larson fish quarries, former commercial sites, are located within the monument.
	Road Hollow Member (Tgrh)	Laminated limestones, kerogen-rich laminated micrites, and ostracodal, gastropodal, and bioturbated limestone interbedded with red and brown sandstones, siltstone, mudstone, and gray to green claystone; some tuff beds; fossils in laminated units are similar to **Tgfb**. Grades to the west and south into **Tw**. **Tgul**: Upper Limestone bed. Golden-brown layers of alternating limestone, siltstone and mudstone; limestones contain invertebrate fossils; a thin unit of kerogen-rich laminated micrite occurs at the base and grades upward into siltstone and mudstone; grades laterally into **Tw**. **Tgwm**: Lower White Marker bed. Distinctive white color due to weathering of kerogen-rich laminated micrite and calcimicrite; beds may be quite chalky and form long benches; grades into **Tw** towards the lake margin. **Tgls**: Lower Shale bed. Brown and greenish-gray units of alternating mudstone, laminated calcimicrite, and siliceous calcimicrite; grades southward and westward into **Tw**. Grades into **Tw** towards the lake margin.	*Paleontological Resource Management:* Documentation, inventory, monitoring, and protection. *Energy Resource Exploration and Development:* Areas east and west of the monument that contain "oil shale" (kerogen-rich laminated micrite) may be leased for future development. *Mass Wasting:* Forms lower slopes beneath **Tgfb**. No significant geologic issues. **Tgul**, **Tgwm**, and **Tgls** are not mapped as individual units within the monument at the scale of 1:24,000.	*Eocene Paleontological Resources:* Fish in laminated micrites: *Knightia*, *Diplomystus*, *Asineops*, *Priscacara*, *Phareodus*. Abundant fish coprolites. Gastropods in biotrubated micrites. Some bivalves. Ostracods common in limestones and laminated micrites. Rare crocodile teeth (south of Little Muddy Creek). Bird, turtle, mammal bones in one sandstone unit. Plant leaves and fragments in several units. **Tgul**: Abundant gastropods and ostracods, and pelecypods. **Tgwm**: Kerogen-rich laminated micrite units appear almost black due to their high organic content at Chicken Creek; abundant fossils (fish, ostracods, insects and plant remains). **Tgls**: Abundant fossils of fish and ostracods. *Stratigraphic Features:* The best-developed lacustrine sequence is in the vicinity of Road Hollow (type section) and Chicken Creek in the central part of Fossil Basin. Kerogen-rich and kerogen-poor laminated micrites.	*The Global Greenhouse and Great Lakes of Wyoming:* Represents the initial, overfilled phase of Fossil Lake between approximately 53.5 million and 52.0 million years ago. This is a new member described by Buchheim et al. (2011), who also propose formal recognition of the stratigraphic units: **Tgul**, **Tgwm**, and **Tgls**. **Tgwm**: Predominance of kerogen-rich laminated micrites interbedded with a few siliciclastic units suggests a deeper stage of the lake and corresponds to major transgressions that deposited thinner, kerogen-rich layers as far south as Sheep Creek.

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Age			Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
PALEOGENE	Eocene	Wasatch Formation	Tunp Member (Twt)	Diamictite (rock with a variety of particle sizes); red mudstone matrix with large angular blocks up to 6+ m (20+ ft) slumped and shed off local terrain. Thickness: 30–152 m (100–500 ft) thick.	Not mapped within the monument. Deposited along the periphery of Fossil Basin, associated with thrust faults.	*Stratigraphic Features:* Marginal unit of the Wasatch Formation restricted to the northwestern margin of Fossil Basin.	*The Global Greenhouse and Great Lakes of Wyoming:* Probably originated from mudflows and gravity sliding that resulted in the coarse, unsorted debris deposit.
			Bullpen Member (Twb)	Variegated red, gray, and green mudstone; interbeds of gray and tan sandstone, brown laminated limestone, and light-gray shale; grades into lacustrine interbedded mudstone and limestones toward the east in the area of the South Fork of Twin Creek; up to 120 m (390 ft) thick. Forms low hills mostly west and south of the monument.	*Paleontological Resource Management:* Fossils have not been documented in **Twb** within the monument. *Mass Wasting:* Bentonite, a clay mineral that swells when wet and shrinks upon drying, is present in some claystone beds and may cause slumping.	*Eocene Paleontological Resources:* No fossils in the monument, but gastropods, gars, and the extinct fish *Asineops*, are known from the member. *Presbyornis* nesting site. *Stratigraphic Features:* Transition from lake environment (**Tga**) to a swamp and floodplain environment.	*The Global Greenhouse and Great Lakes of Wyoming:* Deposited across the entire Fossil Basin after Fossil Lake ceased to exist. Deposition of this uppermost member of the Wasatch Formation ends before 50 million years ago (Early Eocene).
			Main body (Tw)	Primarily red, maroon, yellow, and gray variegated mudstone and claystone with beds of brown, yellow, and gray fine to coarse grained sandstone and conglomerate; other lithologies include diamictite, marlstone, and pisolitic limestone; coarsens toward the west. Up to 450 m (1,500 ft) thick in the northern part and 320 m (1,000 ft) thick in the southern part of Fossil Basin.	*Paleontological Resource Management:* Documentation, inventory, monitoring, and protection. *Mass Wasting:* Unstable slopes due to bentonitic claystones. Potential for landslides, which undercut the more resistant, blocky limestone of the Green River Formation and may cause rockfall.	*Eocene Paleontological Resources:* Only fossiliferous member of the Wasatch Formation within the monument. Includes 39 genera of mammals and 8 reptile genera (table 2). *Stratigraphic Features:* Spectacular red-colored badlands are particularly well-exposed at the saddle between Fossil Butte and Cundick Ridge. Channel-fill and floodplain deposits.	*The Global Greenhouse and Great Lakes of Wyoming:* Deposited in floodplains and stream channels. Locally, may overlap the Evanston Formation or may rest directly on Mesozoic or Paleozoic strata. The Wasatch Formation begins in Fossil Basin about 53.5 million years ago (Early Eocene).
			Southern Mudstone Tongue (Twms)	Red mudstone, shale and sandstone derived from the Wasatch Formation in the northern part of the monument. Pinches out toward the south (basinward). Up to 40 m (130 ft) thick.	*Paleontological Resource Management:* Fossils have not yet been documented in **Twms** within the monument. No significant issues.	*Eocene Paleontological Resources:* Beyond the monument boundaries, **Twms** contains algal logs (logs encrusted by layers of calcium carbonate–producing algae.	*The Global Greenhouse and Great Lakes of Wyoming:* Represents the northern shoreline of Fossil Lake. Possibly deposited in a large delta. Merges with **Twt** to the north and west.
			Sandstone Tongue (Tws)	Brown- weathering gray cross-bedded sandstone and interbedded mudstone; interlayered with **Tgr**, separates **Tgfb** from **Tgrh**. Up to 25 m (82 ft) thick. Limited in distribution to south of the monument. Thins and pinches out before reaching the monument.	Not mapped within the monument.	**Stratigraphic Features**: Forms a conspicuous ledge south of the monument. Cross-bedded, deltaic sandstone. Thickens significantly toward the south.	*The Global Greenhouse and Great Lakes of Wyoming:* Interpreted as a lacustrine Gilbert-type delta with topset, foreset, and bottomset sandstone beds that prograded into the southern part of Fossil Lake until lake level rose.
			Lower Member (Twl)	Gray, brown, and red sandstone and mudstone, carbonaceous claystone, and stromatolitic and pisolitic limestone; locally unconformable with **Tw**. Up to 100 m (330 ft) thick. Exposed in the far western section of the monument just below Prow Point.	*Paleontological Resource Management:* Fossils have not yet been documented in **Twl** within the monument. *Mass Wasting:* No significant issues.	*Eocene Paleontological Resources:* Stromatolites. *Stratigraphic Features:* Intermediate in color and composition between the overlying **Tw** and underlying **Te**.	*The Global Greenhouse and Great Lakes of Wyoming:* Represents floodplain and stream channel deposits and a gradual change in climatic and/or sedimentary conditions in Fossil Basin.
			Basal Conglomerate Member (Twc)	Conglomeratic sandstone composed of Nugget Sandstone clasts; 1–100 meters (3.3–330 ft) thick.	Not mapped within the monument. Only locally exposed in Fossil Basin.	Lenticular conglomerate beds.	*The Global Greenhouse and Great Lakes of Wyoming:* Represents channel sediments that filled stream beds cut into Mesozoic rocks.
	Paleocene	Evanston Formation	Upper unit (Te)	Gray claystone and siltstone; interbeds of tan sandstone, carbonaceous claystone, coal, and boulder conglomerate. Up to 300 m (1,000 ft) thick. Not as colorful as **Tw**.	Not mapped within the monument. Exposed in a belt along the eastern and western borders of Fossil Basin.	Paleocene fossil vertebrate fauna, pollen, and leaves.	*The Great Compression:* Overlies a major pre-Tertiary unconformity. Depositional environments include streams, marshes, and ponds. Not involved in main Absaroka thrusting, suggesting that the thrust was Late Cretaceous and Fossil Basin began forming in the Late Cretaceous and continued in the Paleocene.
			Unconformity				
CRETACEOUS	Upper		Hams Fork Conglomerate Member (Keh)	Boulder to pebble conglomerate of well-rounded quartzite, chert, and limestone; contains beds of gray and brown cross-bedded sandstone and gray mudstone; poorly exposed; 300 m (1,000 ft) thick.	Not mapped within the monument. Exposed east of the monument and west of Cumberland Flats.	Late Cretaceous fossils include: *Triceratops* jaw, gastropods, leaves, pollen, and spores. As many as nine beds of boulder conglomerate interstratified with thick beds of conglomeratic sandstone and mudstone.	*The Great Compression:* Excellent rounding and sphericity of pebbles and boulders suggest moderate transport of the material in a large drainage system. **Keh** is mapped above and below the Absaroka thrust.

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Age		Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
CRETACEOUS	Upper	Adaville Formation: Adaville Formation (Kav)	Gray brown and tan shale and siltstone; gray platy to cross-bedded, bioturbated sandstone; carbonaceous shale; numerous coal beds. Up to 880 m (2,900 ft) thick. Basal part forms ledges and cliffs.	*Energy Resource Exploration and Development:* Source of coal for local mines (i.e., Kemmerer Mine). Not mapped within the monument. Exposed east of the monument and west of Cumberland Flats.	Coal beds up to 35 m (115 ft) thick in the middle and lower parts of the formation. Fossil leaves have been dated to the latest Cretaceous. Bedding is more uniform bedding than in **Keh**.	*The Great Compression:* These units are in the footwall (east) of the Absaroka thrust. Helps date movement on the Absaroka thrust as latest Cretaceous. Bedding structures and marine fossils suggest that the Lazeart Sandstone was a prograding beach sequence.
		Adaville Formation: Lazeart Sandstone Member (Kal)	Light gray to white, yellow-brown to tan, fine- to medium-grained sandstone exposed as thick cliffs with intervening slopes of brownish-gray shale and coal beds; 180 m (590 ft) thick.			
		Hilliard Shale: Hilliard Shale (Kh)	Dark gray to tan claystone, siltstone, and sandy shale; thin interbeds of light-gray sandstone and bentonite.	Not mapped within the monument. Forms the surface of Cumberland Flats, east of the monument.	Abundant marine mollusks, a few ammonites, and palynomorphs.	Interbedded marine shale, siltstone, and sandstone in the footwall (east) of the Absaroka thrust. Deposits associated with the Cretaceous Western Interior Seaway.
		Hilliard Shale: Hinshaw Member (Khh)	Interbedded shale and gray to tan, fine-grained sandstone units 0.3–10 m (1–33 ft) thick. Grades upward into the overlying **Kal**. Overall thickness about 260–305 m (850–1,000 ft).	Exposed in a thin strip along the western margin of Cumberland Flats, east of the monument.	Hummocky bedding, large-scale ball and pillow sedimentary structures, trough cross-bedding. Burrows.	
		Hilliard Shale: Conglomerate of Little Muddy Creek (Khc)	Conglomerate and sandstone; conglomerate primarily well rounded Mesozoic and Paleozoic boulders derived from the upper plate of the Absaroka thrust. Maximum thickness about 610 m (2,000 ft).	Exposed along Little Muddy Creek, southeast of the monument on Cumberland Flats.	Boulders up to 2 m (7 ft) in diameter.	
		Frontier Formation: Frontier Formation (Kf)	Sandstone, siltstone, and carbonaceous shale with thick interbeds of coal; porcellanite (white volcanic ash) and conglomerate interbeds; up to 670 m (2,200 ft) thick.	Not mapped within the monument. The Frontier Formation and its members are exposed along the western slope of the north–south-trending Oyster Ridge, east of Kemmerer and Cumberland Flats.	Coal. Porcellanite. Palynomorphs.	Nonmarine and marine units record nearshore depositional environments associated with the Cretaceous Western Interior Seaway. Formation is in the footwall (east) of the Absaroka thrust.
		Frontier Formation: Lower Unit (Kfl)	White sandstone interbedded with siltstone, carbonaceous shale, coal beds, porcellanite, and conglomerate.		Coal. Porcellanite.	
		Frontier Formation: Dry Hollow Member (Kfd)	Gray, greenish-gray, and tan nonmarine shale and siltstone; interbeds of tan and brown coal and fine- to medium-grained sandstone; approximately 100–130 m (330–430 ft) thick.		Kemmerer coal bed near the top under a 3-m- (10-ft-) thick sandstone that contains a marine fauna. Sandstone is platy to cross-bedded; locally bioturbated.	
		Frontier Formation: Conglomerate Member (Kfdc)	Not an official member. Conglomerate that locally forms channels that cut into **Kfo**.		Channel-shaped deposits of conglomerate.	
		Frontier Formation: Oyster Ridge Sandstone Member (Kfo)	Light tan to white sandstone, medium-grained, planar to cross bedded, with interbeds of brown shale; forms cliffs; 24–35 m (79–115 ft) thick.	Not mapped within the monument. The Frontier Formation and its members are exposed along the western slope of the north–south-trending Oyster Ridge, east of Kemmerer and Cumberland Flats.	Sandstone is parallel-bedded to cross-bedded and contains marine fauna indicative of a marine shoreline environment.	Nonmarine and marine units record nearshore depositional environments associated with the Cretaceous Western Interior Seaway. The formation is primarily in the footwall (east) of the Absaroka thrust and in the hanging wall of the Darby thrust that formed Oyster Ridge, but it is also in the hanging wall (west) of the Absaroka thrust south of Muddy Creek where a kink is present in the north–south-trending thrust fault.
		Frontier Formation: Allen Hollow Member (Kfa)	Dark-gray to greenish-brown shale, siltstone and sandstone; covered slopes; approximately 92 m (300 ft) thick.		*Collignoniceras woolgari* fauna.	
		Frontier Formation: Coalville Member (Kfc)	Dark greenish-gray shale interbedded with tan sandstone that is fine-grained, cross-bedded, ripple-marked, and bioturbated; 24–46 m (70–150 ft) thick.		Flaggy to cross-bedded, ripple-marked, bioturbated sandstone with brackish-water to marine fauna.	
		Frontier Formation: Chalk Creek Member (Kfcc)	Greenish-gray to brown, nonmarine shale, bentonitic shale, tuff and tuffaceous sandstone; platy to cross-bedded, locally bioturbated; approximately 300–400 m (1,000–1,300 ft) thick.		Platy to cross-bedded sandstone, coal, nonmarine shale, and molluscan fauna represent nearshore depositional environments.	
	Lower	Aspen Shale (Ka)	Light to dark gray shale and quartzite sandstone; porcellanite forms prominent ridges; unit contains fish scales, palynomorphs, and mollusks; 245–370 m (809–1,220 ft) thick.	Not mapped within the monument. Exposed on Oyster Ridge, east of Kemmerer and Cumberland Flats.	Fish scales, palynomorphs, and molluscan fauna.	Represents deposition associated with the developing Cretaceous Western Interior Seaway. These units are in the footwall (east) of the Absaroka thrust. The Darby thrust, also a product of the Sevier Orogeny, formed Oyster Ridge.
		Bear River Formation (Kbr)	Dark gray carbonaceous shale, olive-tan sandstone, and limestone containing the abundant gastropod (*Pyrgulifera*) and pelecypod fauna that frequently blankets the weathered slopes; poorly exposed, forms slopes; 200–400 m (660–1,300 ft) thick.		Gastropod (*Pyrgulifera*) and pelecypods fossils. Palynomorphs.	
		Thomas Fork Formation (Ktf)	Interbedded buff sandstone and reddish-brown mudstone containing gray limestone nodules averaging 2–3 cm across; thickens southward from 100–400 m (330–1,300 ft) thick.	Not mapped within the monument. Located in the upper plate (hanging wall) of thrust faults and broken into fault slices by normal faults in the highlands west of the monument.	Limestone nodules. Merges to the south, and is lithologically indistinguishable from, the upper part of the Kelvin Formation (Lower Cretaceous) in northeastern Utah.	Displaced and deformed by thrust faults and normal faults associated with the Sevier Orogeny. Located above (west of) the Absaroka thrust fault.

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CRETACEOUS	Lower	Smiths Formation (Ks)	Tan quartzite or fine grained sandstone with black carbonaceous shale at its base; up to 120 m (400 ft) thick.	Not mapped within the monument. Located in the upper plate (hanging wall) of thrust faults and broken into fault slices by normal faults in the highlands west of the monument.	Black, carbonaceous shale at the base of the unit.	Displaced and deformed by thrust faults and normal faults associated with the Sevier Orogeny. Located above (west of) the Absaroka thrust fault.
		Gannett Group (Kg, Kgc, Ke)	**Kg**: Gannett Group. Brick-red and orange-brown to maroon mudstone, siltstone, and sandstone with a few interbeds of limestone and conglomerate; 640 m (2,100 ft) thick. **Kgc**: Chert pebble conglomerate beds; approximately 1 m (3.3 ft) thick. **Ke**: Ephraim Conglomerate. Red to tan cross-bedded sandstone, and massively bedded conglomerate with abundant black chert pebbles; up to 200 m (660 ft) thick.	Not mapped within the monument. Located in the upper plate (hanging wall) of thrust faults and broken into fault slices by normal faults in the highlands west of the monument and on the eastern side of Oyster Ridge.	Interbedded limestone, mudstone, siltstone, sandstone, and conglomerate beds. Cross-bedded to massive.	
JURASSIC	Upper	Stump Sandstone and Preuss Red Beds (Jsp)	**Stump Sandstone**: Greenish-gray sandstone and limestone. **Preuss Red Beds**: Red to purplish-gray sandstone and silty claystone with thin beds of red to tan sandstone. Unit thickens to 520 m (1,700 ft) west of the Crawford fault.	Not mapped within the monument. Exposed in the upper plate of the Tunp thrust, west of the monument, and on the eastern slope of Oyster Ridge, east of the monument.	Because the unit is thin, the Stump Sandstone has been mapped with the Preuss Red Beds in the area.	*Assembling and Dismantling Pangaea:* Deposited along the southern margin of a shallow sea that encroached into southwestern Wyoming during the Middle Jurassic as Pangaea separated.
	Middle	Twin Creek Limestone (Jt, Jtg)	**Jt**: Sandy argillaceous thin bedded limestone and red calcareous siltstone in the lower part. Forms conspicuously bare slopes; massive oolitic limestone beds. Up to 880 m (2,600 ft) thick west of the monument and 240–300 m (790–1,000 ft) thick east of the monument. **Jtg**: Gypsum Spring Member. Red calcareous mudstone and siltstone and gray limestone breccia. Up to 30 m (100 ft) thick.	Not mapped within the monument. Exposed in the upper plate of the Tunp thrust, west of the monument, and on the eastern slope of Oyster Ridge, east of the monument.	**Jt**: Limestone contains the distinctive crinoid fossil, *Pentacrinus*. In cross-section, the crinoid stem is pentagonal or star-shaped. **Jtg**: Breccia believed to be formed by solution, or leaching, of anhydrite and subsequent collapse of overlying limestone.	*Assembling and Dismantling Pangaea:* **Jt**: Abundant crinoids suggest that the limestone formed in a marine environment with well-circulating bottom currents. **Jtg**: Represents deposition in marine to hypersaline marine or coastal sabkha and tidal flat environments.
	Lower	Nugget Sandstone (JTRn)	Buff, pink, and white quartzite and sandstone; massive to cross-bedded; fine to medium grained, well sorted; up to 450 m (1,500 ft) thick in the Tunp Range and 200 m (700 ft) thick east of the monument.	Not mapped within the monument. Exposed on Rock Creek Ridge (upper plate of the Tunp thrust), west of the monument, and east of Oyster Ridge, east of the monument.	Forms prominent ridges and cliffs with blocky talus slopes. Massive to eolian cross-bedded sandstone.	*Assembling and Dismantling Pangaea:* Part of an extensive sand sea (erg). Early Jurassic in age according to the U.S. Geological Survey.
TRIASSIC	Upper	Ankareh Red Beds (TRa)	Red and maroon calcareous sandstone or quartzite; siltstone, sandy calcareous mudstone, and some local beds of red to green-gray limestone near the middle of the formation; 225 m (740 ft) thick.	Not mapped within the monument. Exposed west of the monument.	Greater proportion of sandstone than Woodside Red Beds (**TRw**).	*Assembling and Dismantling Pangaea:* Deposited over the Thaynes Limestone as the shallow sea withdrew from southwestern Wyoming.
	Mid.	Unconformity				
	Lower	Thaynes Limestone (TRt)	Gray, silty erosion-resistant limestone and calcareous siltstone; thickness increases to the north and west from 215–400 m (710–1,300 ft) thick. Mapped near the northwestern corner of the monument.	**Paleontological Resource Management**: Documentation, inventory, monitoring, and protection.	*Triassic Paleontological Resources:* Contains a varied assemblage of marine invertebrate fossils, mostly oysters and clams. Fossils not yet discovered within the monument.	*Assembling and Dismantling Pangaea:* Represents another incursion of a shallow sea into the area.
		Woodside Red Beds (TRw)	Red siltstone and claystone with thin interbeds of red sandstone and gray limestone. Up to 200 m (660 ft) thick. Forms slopes.	Not mapped within the monument. Exposed in the Tunp Range, west of the monument.	Nonresistant sequence of siltstone and claystone forms slopes.	*Assembling and Dismantling Pangaea:* Deposited over the Wyoming shelf as sea level fell.
		Dinwoody Formation (TRd)	Greenish-gray calcareous siltstone, claystone, and argillaceous sandy limestone; thin bedded. Thickness: 30–150 m (100–490 ft).		Weathers tan to buff-gray. Distinctive thin layers of siltstone and claystone above the Phosphoria Formation (**Pp**).	*Assembling and Dismantling Pangaea:* Represents initial incursion of a shallow sea onto the gently westward-sloping Wyoming shelf.
PERMIAN	Middle-Upper	Unconformity				
	Lower	Phosphoria Formation	Phosphoria Formation (Pp)	Dark-gray siltstone, thin-bedded limestone, dolomitic limestone, and black chert. Thickness: 130 m (430 ft).	*Energy Resource Exploration and Development:* Source of phosphate rock and associated vanadium, gypsum, and oil and gas in the subsurface. Not mapped within the monument. Exposed to the west in the Tunp Range.	Invertebrate marine fossils (brachiopods and conodonts).	*Ancient Seas:* Represents deposition in shallow marine water that received nutrients from upwelling currents, which provided phosphorus for the hard parts of marine invertebrates and fecal pellets.
			Upper Part (Ppu)	Dark-gray siltstone, thin-bedded limestone and black chert. Several chert beds.		Resistant ledges of red to gray dolomitic limestone and chert.	
			Lower Part (Ppl)	Dark phosphatic siltstone, gray dolomite, and thin-bedded black chert and limestone.		Phosphatic rock and vandiferous carbonaceous siltstone that has vanadinite, a mineral containing vanadium and lead.	

Colored rows indicate units mapped within Fossil Butte National Monument. Italicized text refers to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
PENNSYLVANIAN	Wells Formation (PlPw, Pwl)	**PlPw**: Wells Formation. Light-gray, fine-grained sandstone and quartzite with beds of dolomite and limestone. Total thickness is 185–305 m (610–1,000 ft). **Pwl:** Wells Formation limestone. Gray limestone, 80 m (260 ft) thick.	*Energy Resource Exploration and Development:* Source of silica sand, limestone for road aggregate, and oil and gas in the subsurface. Not mapped within the monument. Well exposed along the crest of Dempsey Ridge and near the base of the Absaroka thrust sheet on Commissary Ridge.	Invertebrate marine fossils in the limestone.	*Ancient Seas:* Represents deposition in marine environments.
MISSISSIPPIAN Upper	Amsden Formation (PMa)	Reddish-gray to black cherty limestone and limestone breccia with interbeds of yellowish-red sandstone and quartzite and red to yellow siltstone and claystone. Thickens west to east from 45 to 120 m (150 to 390 ft).	In the subsurface, **PMa** may act as a confining unit (low porosity and permeability) to underlying groundwater aquifers. Not mapped within the monument. The upper part of the formation is exposed where Little Beaver Creek crosses Dempsey Ridge in the Tunp Range.	Invertebrate marine fossils.	*Ancient Seas:* Contains limestone and dolomite deposited in shallow, near-shore marine environments as well as terrigenous sediment eroded from the Ancestral Rocky Mountains.
MISSISSIPPIAN Mid.	Unconformity				
MISSISSIPPIAN Lower / DEVONIAN Upper	Darby Formation (MDd)	Dark gray or brown fetid (malodorous) dolomite, massive to medium bedded with interbeds of black, yellow and red sandy calcareous siltstone in upper part; approximately 270 m (890 ft) thick.	Not mapped within the monument. Exposure with limited areal extent located west of Sillem Ridge, west of the monument.	Fetid odor commonly results from decaying organic matter.	Shallow, peritidal deposition on the eastern coast of the inland sea that spread into Wyoming as a result of the Antler Orogeny.

Reference maps: Buchheim, H. P. 2005. Geologic map of Fossil Butte National Monument and vicinity, Wyoming. Unpublished. Loma Linda University, Loma Linda, California, USA (scale 1:24000); and Lowry, J. 2007. Digital geologic map of Fossil Butte National Monument and vicinity, Wyoming. Unpublished. Utah State University, Logan, Utah, USA (scale 1:24000).