

INTERIM GEOLOGIC MAP OF THE BRYCE CANYON QUADRANGLE, GARFIELD COUNTY, UTAH

by

Tyler R. Knudsen¹ and Robert F. Biek²

¹ Utah Geological Survey, Salt Lake City, Utah

² Utah Geological Survey, retired, Fort Bragg, California

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SUMMARY

The Bryce Canyon 7.5' quadrangle is centered on the Paunsaugunt Plateau in the High Plateaus subsection of the Colorado Plateau physiographic province. The quadrangle encompasses the community of Bryce Canyon City, part of Bryce Canyon National Park (BCNP), and adjoining Dixie National Forest lands. The gently north-tilted surface of the Paunsaugunt Plateau sits at an average elevation of about 8000 feet (2400 m) and is drained northeastward by the East Fork Sevier River. Exposed bedrock in the Bryce Canyon quadrangle consists of a sequence of sedimentary rocks ranging in age from Late Cretaceous to Eocene. These rock units represent a 3500-foot (1065 m) section of fluvial, lacustrine, deltaic, and flood plain environments. Cretaceous Straight Cliffs, Wahweap, and Kaiparowits strata were deposited in fluvial and flood-plain environments along the western margin of the Late Cretaceous Western Interior Seaway. The Paleocene to Eocene Claron Formation was deposited in fluvial, floodplain, and lacustrine environments of an intermontane basin bounded by Laramide and Sevier uplifts. Claron strata typically weather to gently rolling hollows and hills. However, along the plateau's eastern rim, rapid erosion of the Claron Formation by the Paria River system has sculpted steep-walled amphitheaters adorned with vertical spires, hoodoos, and slot canyons—collectively known as the Pink Cliffs that are showcased in BCNP. The Rubys Inn and Pine Hills thrust faults are major east-west-trending, mid-Tertiary (Neogene) thrust faults that bisect the quadrangle and define the margins of Emery and Johns Valleys (e.g., Lundin, 1989; Bowers, 1991; Davis, 1999; Biek et al., 2015; Davis and Pollock, 2024). The faults generally place Late Cretaceous strata onto the Paleogene pink member of the Claron Formation. Research over the past 35 years has shown that the Rubys Inn and Pine Hills thrust faults are part of the larger Paunsaugunt thrust fault system that developed in response to gravitational spreading of the Marysvale volcanic field about 20 to 30 million years ago (e.g., Nickelsen et al., 1992; Davis and Rowley, 1993; Merle et al., 1993; Davis, 1999; Biek et al., 2015; Davis and Pollock, 2024). Stream alluvium and terrace deposits of different ages are present along larger drainages, including the East Fork Sevier River. Alluvial pediment deposits blanket much of Emery and Johns Valleys.

MAP UNIT DESCRIPTIONS

QUATERNARY

Human-derived deposits

- Qh **Artificial fill** (Historical) – Areas obscured by human activity including sand and gravel pits, and the construction of sewage lagoons and large building pads; minor fill placed for roadways, small building pads, and stock ponds; mapped where geologic contacts may be obscured by fill; 0 to 30 feet (0–9 m) thick.

Alluvial deposits

- Qa₁ **Stream alluvium** (Holocene) – Stratified, moderately to well-sorted clay, silt, sand, and pebble to boulder gravel; deposited in stream channels and floodplains; subangular to subrounded clasts; locally includes minor alluvial-fan, colluvial, and low-level terrace deposits; thickness generally less than 30 feet (9 m).
- Qay **Younger stream alluvium** (Holocene to Late Pleistocene) – Moderately sorted clay, silt, sand, and pebble to boulder gravel; deposited in low-gradient stream channels and floodplains; subangular to subrounded clasts; comprises combined stream alluvium (Qa₁) and the youngest (lowest elevation) part of level-1 stream-terrace alluvium (Qat₁), but undivided here due to limitations of map scale; includes abandoned channels and floodplains along active channels of the East Fork Sevier River; locally includes small alluvial-fan deposits from adjacent minor drainages and colluvium from adjacent slopes too small to map separately; thickness generally less than 20 feet (6 m), but may locally exceed 30 feet (9 m) along East Fork Sevier River.
- Qat₁ **Level-1 stream-terrace deposits** (Holocene to Late Pleistocene?) – Moderately to well-sorted clay, silt, sand, and gravel; forms gently sloping terraces above active channels; subangular to rounded clasts; deposited in a stream-channel environment along East Fork Sevier River and near the mouth of Fairyland Canyon below the Pink Cliffs; forms terraces about 3 to 25 feet (1–8 m) above modern drainages; probably less than 20 feet (6 m) thick.
- Qat₂ **Level-2 stream-terrace deposits** (Late Pleistocene?) – Moderately to well-sorted clay, silt, sand, and gravel; forms gently sloping terraces about 25 to 50 feet (8–15 m) above adjacent drainages; subangular to rounded clasts; probably less than 20 feet (6 m) thick.

- Qat₃** **Level-3 stream-terrace deposits** (Late Pleistocene?) – Moderately to well-sorted clay, silt, sand, and gravel; forms gently sloping terraces about 50 to 70 feet (16–21 m) above adjacent drainages; subangular to rounded clasts; probably less than 20 feet (6 m) thick.
- Qaf₁** **Level-1 fan alluvium** (Holocene) – Poorly to moderately sorted, subangular to subrounded, clay- to boulder-size sediment; deposited principally by debris flows and debris floods at the mouths of active drainages; surface is modern and generally undissected; equivalent to the younger part of younger fan alluvium (**Qafy**), but differentiated because **Qaf₁** typically forms smaller, isolated fans; less than 30 feet (9 m) thick.
- Qaf₂** **Level-2 fan alluvium** (Middle Holocene to Late Pleistocene) – Poorly to moderately sorted, subangular to subrounded, clay- to boulder-size sediment; deposited principally by debris flows and debris floods; forms mostly inactive, moderately incised surfaces cut by younger stream and fan deposits; equivalent to the older part of younger fan alluvium (**Qafy**); less than 30 feet (9 m) thick.
- Qafy** **Younger fan alluvium** (Holocene to Late Pleistocene) – Poorly to moderately sorted, non-stratified, subangular to subrounded, boulder- to clay-size sediment; deposited at the mouths of streams and washes; forms both active depositional surfaces (**Qaf₁** equivalent) and low-level mostly inactive surfaces incised by small streams (**Qaf₂** equivalent) that are undivided here; deposited principally as debris flows and debris floods; colluvium locally constitutes a significant part of the deposits; generally less than 30 feet (9 m) thick.
- Qafo** **Older fan alluvium** (Early? to Late Pleistocene) – Light-tan, poorly to moderately sorted, non-stratified, subangular to subrounded, clay- to boulder-size sediment with moderately developed pedogenic carbonate; forms broad, gently sloping, dissected surfaces; deposited principally as debris flows and debris floods; prominent clasts include limestone, chert, and quartzite derived from the Claron Formation, and yellowish-brown Cretaceous sandstone; locally contains subordinate volcanic-rock clasts; exposed thickness as much as 40 feet (12 m).
- Qap** **Pediment alluvium** (Holocene to Late Pleistocene) – Poorly sorted silt, sand, and gravel containing subangular to rounded clasts that form a locally resistant cap on eroded bedrock surfaces incised by modern drainages; deposited principally as debris flows, debris floods, and in ephemeral stream channels; along the Pink Cliffs rim, **Qap** locally includes eolian sand deposits too small to map separately; as much as 50 feet (15 m) thick.
- Qapo** **Older pediment alluvium** (Pleistocene) – Poorly sorted silt, sand, and gravel containing subangular to rounded clasts; forms a locally resistant cap on eroded bedrock surfaces, but is more deeply dissected than **Qap** and is commonly preserved as erosional remnants of formerly extensive pediment deposits; remnants represent multiple surfaces from several tens of feet to more than 200 feet (60 m) above modern drainages; as much as 50 feet (15 m) thick.

Colluvial deposits

- Qc** **Colluvium** (Holocene to Late? Pleistocene) – Poorly to moderately sorted, angular to subrounded, clay- to boulder-size, locally derived sediment; deposited principally by slope wash and soil creep on moderate slopes and in shallow depressions; a patchy, thin veneer of colluvium and regolith blankets much of the Claron Formation on the Paunsaugunt Plateau; deposit is mapped only where it conceals contacts or fills broad depressions; locally includes talus and alluvial deposits too small to map separately; eolian sand is a common component of **Qc** along the Pink Cliffs rim; typically less than 20 feet (6 m) thick.
- Qco** **Older colluvium** (Late? Pleistocene) – Poorly to moderately sorted, angular, clay- to boulder-size, locally derived sediment; deposited principally by slope wash and soil creep; forms gently sloped, moderately resistant benches deeply incised by modern drainages; locally includes talus and alluvial deposits too small to map separately; typically less than 40 feet (12 m) thick.

Mass-movement deposits

- Qmsh** **Historical landslide deposits** (Historical) – Light-brown and reddish-brown, very poorly sorted, clay to boulder-size material derived from the Wahweap Formation; deposited principally by rotational and translational

movement; characterized by hummocky topography, internal scarps, chaotic bedding attitudes, small ponds, and marshy depressions; mapped near the head of Tropic Canyon where historical movement has repeatedly damaged State Route 12 (Knudsen, 2026); several tens of feet thick.

- Qms** **Landslide deposits** (Holocene to Late? Pleistocene) – Very poorly sorted, locally derived material deposited principally by rotational and translational movement; locally includes flow-style deposits with lobate morphology; composed of clay- to boulder-size debris as well as large, partly intact bedrock blocks; characterized by hummocky topography, internal scarps, and chaotic bedding attitudes; all mapped landslides in the Bryce Canyon quadrangle appear to have initiated in the clay-rich Wahweap Formation; age and stability determinations require detailed geotechnical investigations; mapped landslides are generally less than 100 feet (30 m) thick.
- Qmso** **Older landslide deposits** (Late? to Middle? Pleistocene) – Light-pink and light-orange, very poorly sorted, clay to boulder-size material derived principally from the Claron Formation; deposited principally by rotational and translational movement; includes large, partly intact bedrock blocks; deposits are deeply dissected and cap ridges, indicating a likely Pleistocene age; locally includes residual talus, colluvium, and other cliff-retreat deposits; age and stability determinations require detailed geotechnical investigations; thickness highly variable, but locally exceeds several hundred feet.
- Qmt** **Talus** (Holocene to Late Pleistocene) – Poorly sorted, angular cobbles and boulders and finer-grained interstitial sediment; deposited principally by rockfall on or at the base of steep slopes and cliffs; talus is common at the base of steep slopes across the map area, but is only mapped where it conceals contacts or forms broad aprons below cliffs of resistant bedrock units; typically grades downslope into colluvium and combined where impractical to differentiate the two; may also include alluvium in the bottom of washes; typically less than 30 feet (9 m) thick.

Mixed-environment deposits

- Qac** **Alluvium and colluvium** (Holocene to Late Pleistocene?) – Poorly to moderately sorted, generally poorly stratified, clay- to boulder-size, locally derived sediment; deposited in swales and small drainages by fluvial, slope-wash, and creep processes; gradational with alluvial and colluvial deposits; generally less than 20 feet (6 m) thick.
- Qaco** **Older alluvium and colluvium** (Late Pleistocene?) – Poorly to moderately sorted, generally poorly stratified, clay- to boulder-size, locally derived sediment; deposited in swales and small drainages by fluvial, slope-wash, and creep processes; forms incised, isolated remnants, typically along the upper reaches of streams; generally less than 20 feet (6 m) thick.
- Qmtc** **Talus and colluvium** (Holocene to Late Pleistocene) – Poorly sorted, angular to subangular, cobble- to boulder-size and finer-grained interstitial sediment deposited principally by rockfall and slope wash on steep slopes; includes minor alluvial sediment at the bottom of washes; typically grades downslope to alluvium; generally less than 30 feet (9 m) thick.

Residual deposits

- Qr** **Residium** (Holocene to Middle? Pleistocene) – Mapped where light-brown, very poorly sorted, sand to boulder-size material—derived principally from the conglomerate at Boat Mesa (**Tbm**)—caps a few low hills near the eastern escarpment of the Paunsaugunt Plateau; includes rotated, intact blocks of **Tbm** and unconsolidated piles of **Tbm**-derived, rounded, chert and quartzite pebbles resting on Claron Formation; probably less than 20 feet (6 m) thick.

Stacked unit deposits

- Qc/Tcp** **Colluvium over the pink member of the Claron Formation** (Holocene to Late Pleistocene/Eocene) – Poorly to moderately sorted, angular to subrounded, clay- to boulder-size, locally derived sediment deposited principally by slope wash and soil creep on moderate slopes and in shallow depressions; mapped where a discontinuous veneer of colluvium and regolith covers low benches cut across the pink member of the Claron Formation along East Creek and Daves Hollow; locally includes talus and alluvial deposits too small to map separately; surficial cover typically less than about 10 feet (3 m) thick.

unconformity

TERTIARY

Taf Basin-fill deposits (Pliocene? to Miocene?) – Light purplish-gray, poorly sorted, moderately to poorly consolidated, non-stratified, subangular to subrounded, gently west-dipping volcanoclastic sand and gravel; locally contains subordinate clasts of quartzite and Claron Formation limestone; equivalent deposits were interpreted by Bowers (1991) (his unit QTsr) to be derived from the southern Sevier Plateau; maximum exposed thickness is about 60 feet (18 m).

unconformity

Tbm Conglomerate at Boat Mesa (Middle to Late Eocene?) – Upper 30 feet (9 m) consists of medium- to thick-bedded, white to light-gray, calcareous pebbly sandstone, conglomerate, and conglomeratic limestone; lower 30 to 50 feet (9–15 m) is light-brown to light-gray, medium- to thick-bedded conglomerate and lesser conglomeratic sandstone and siltstone; forms prominent cliff that caps the unit's namesake Boat Mesa in Bryce Canyon National Park; clasts are rounded pebbles of black chert, brown, gray, and distinctive greenish quartzite, and lesser Paleozoic limestone; no volcanic or intrusive clasts are present; in the limestone intervals, clasts commonly appear to float in a carbonate mud matrix, but otherwise the conglomerates are clast supported; yellow siltstone rip-ups are common above the unconformable contact with the underlying middle mudstone unit of the Claron Formation's white member (Tcwm); slope-forming, variegated mudstone, yellow siltstone, and lesser conglomeratic sandstone mapped as the lower unit of the conglomerate at Boat Mesa (Tbml) by Biek et al. (2015) is here assigned to the underlying middle mudstone unit of the Claron Formation (Tcwm); represents mostly fluvial and overbank deposits incised into the Claron Formation (Davis and Pollock, 2024); Biek et al. (2015) reported a U-Pb maximum depositional age on detrital zircon of 37.97 ± 1.78 –2.70 Ma from a sample collected from the southwestern Sevier Plateau; based on detrital zircon age-spectra analysis, Cull (2025) identified an eastward provenance shift for regional Tbm material, transitioning from a Mesozoic Sierran arc source to a Proterozoic source in the uplifted Nevadaplano of the Sevier hinterland; thickness ranges from about 60 to 80 feet (18–25 m).

unconformity

Claron Formation (Middle Eocene to Paleocene?) – Claron Formation strata are among the most visually striking rocks in the western U.S. and are prominently displayed at Cedar Breaks National Monument and Bryce Canyon National Park. Differential erosion of the Claron Formation has formed the hoodoos, spires, windows, and intricately carved fins and canyons that attract millions of tourists to Bryce Canyon National Park each year.

The Claron Formation has a complicated nomenclatural history (see discussions in Anderson and Rowley [1975] and Biek et al. [2015]) and was originally identified as the Wasatch Formation on the Paunsaugunt Plateau by Gregory (1951). We follow the naming convention of Biek et al. (2015) who mapped the Claron Formation as two informal members, in descending order: the white member (which is divided into an uppermost mudstone interval, an upper limestone interval, a middle mudstone and sandstone interval, and a lower limestone interval) and the lower pink member. An unconformity beneath the overlying conglomerate at Boat Mesa cuts out many of the upper units of the white member in the map area.

Claron strata were deposited in fluvial, floodplain, and lacustrine environments of an intermontane basin bounded by Laramide and Sevier uplifts. The lower pink member is almost entirely fluvial, and the white member is both lacustrine and fluvial (Goldstrand, 1990, 1991, 1992, 1994; Bown et al., 1997). Ott (1999) recognized a 130-foot-thick (40 m) interval of mostly medium-bedded bioclastic limestone and thin-bedded micritic limestone with gastropods, ostracods, charophytes, and algal filaments in the lower part of the pink member in Bryce Canyon National Park. Much of the pink member, and clastic parts of the white member, were greatly modified by bioturbation and pedogenic processes, creating a stacked series of paleosols (Mullett et al., 1988a, 1988b; Mullett, 1989; Mullett and Wells, 1990). Ott (1999) reported depositional cyclicity within the Claron Formation at Bryce Canyon National Park, with multiple regressive cycles, each with increasing pedogenesis toward its top. Bown et al. (1995a, 1995b, 1997) reported on trace fossils of ants, wasps, and bees in the upper part of the pink member and lower part of the white member, recording nest activity during paleosol formation. Eaton et al. (2018) discovered the first vertebrate fossils in the pink member of the Claron Formation at Sweetwater Creek, west of the Table Cliff Plateau east of this map area, that included crocodilians, fish, anurans (frogs and toads), lizards, and mammals. They reported that fossil eggshell is relatively common throughout the Claron Formation, suggesting that vertebrate animals were not necessarily rare during Claron deposition, but rather that there is a strong bias against bone preservation. Detrital zircon studies of the Claron Formation from the Escalante Mountains east of the map area show that the formation there was largely derived from erosion of lower

Paleozoic sandstones exposed in surrounding Laramide uplifts (Link et al., 2007; Larsen et al., 2010). Cull (2025) examined the detrital zircon age spectra of the Claron Formation and noted a dominance of Mesoproterozoic zircons interpreted to be recycled from Neoproterozoic to Mesozoic strata exposed in the Sevier foreland fold and thrust belt. The Claron Formation is typically forested and covered by colluvium and regolith, but along plateau margins it forms the iconic Pink Cliffs, the uppermost riser of the Grand Staircase.

The age of the white member is well constrained as late Middle Eocene (Duchesnean Land Mammal Age), based on limiting U-Pb zircon ages for overlying Brian Head Formation (Rowley et al., 2013; Malone et al., 2025) and conglomerate at Boat Mesa (Biek et al., 2015; Cull, 2025; Malone et al., 2025), and by Late Eocene mammals and ostracods from what we now know to be part of basal Brian Head strata on the Markagunt Plateau (where it was originally misidentified as uppermost Claron Formation [Eaton et al., 2011, 2018]). Along Sweetwater Creek north of Bryce Canyon National Park, Eaton et al. (2018) recovered the Early Eocene (Wasatchian North American Land Mammal Age) rodents *Knightomys reginensis* and *K. minor* from their unit 7, roughly 900 feet (275 m) above their base of the formation in what may be Tcwm equivalent strata. Charophytes recovered from near the base of the lower pink member at Griffin Top, about 3 miles (5 km) north of Sweetwater Creek, suggest an Early Eocene (Ypresian) age for basal Claron strata (Sanjuan and Eaton, 2016). This suggests that the entire Claron Formation in the Bryce Canyon region is Early Eocene in age. However, throughout the western part of its outcrop belt the maximum age of the mostly nonfossiliferous pink member is poorly constrained as Early Eocene to Paleocene(?) (Goldstrand, 1990, 1994; Biek et al., 2015; Sanjuan and Eaton, 2016; Eaton et al., 2018).

Tcwm, Tcwm?

Claron Formation, middle mudstone, siltstone, and sandstone unit of white member (Eocene) – Reddish-orange and yellow, commonly mottled, calcareous mudstone and siltstone, and minor fine-grained, calcareous sandstone; weathers to a multi-colored, poorly exposed slope beneath cliff-forming conglomerate at Boat Mesa; yellow siltstone and sandstone common near the base and top of the unit locally contain rounded chert-pebble stringers; upper unconformable contact corresponds to a color change from multi-colored mudstone and siltstone below to light-gray to light-brown, pebble conglomerate above; we reclassify strata at Boat Mesa—previously mapped as the lower unit of the conglomerate at Boat Mesa (Tbml) by Biek et al. (2015)—as Tcwm, based on lithological similarities to Tcwm mapped elsewhere on the Paunsaugunt Plateau; queried where exposures are poor; the undulating sub-Tbml unconformity has largely removed Tcwm along the Pink Cliffs rim east-northeast of Bryce Canyon National Park’s visitor center; thickness ranges from 0 to about 160 feet (50 m) in the map area.

Tcwl **Claron Formation, lower limestone unit of white member** (Eocene) – Very pale orange, light-pink, and white to light-gray, calcareous mudstone and siltstone and micritic limestone; thick- to medium-bedded; forms slopes with isolated ledges of white limestone; upper contact appears conformable and is placed where light-gray calcareous mudstone of Tcwl is overlain by light-yellow, fine-grained sandstone of Tcwm; about 140 feet (43 m) thick at Boat Mesa.

In southwestern Utah, Tcwl is typically characterized by a bold, white cliff of micritic limestone. North of Inspiration Point, just south of this map boundary, the unit exhibits a sharp transition in facies and outcrop habit from a single limestone cliff to the variegated, slope-forming mudstones and siltstones found in the Bryce Canyon quadrangle. This clastic facies of Tcwl resembles the underlying pink member but is distinctly lighter in color. Bowers (1991) included this clastic interval as part of the pink member and interpreted that the white member is absent in the Bryce Canyon quadrangle. We recognize the clastic interval as age-equivalent to Tcwl and map it northward into Tropic Canyon. The clastic facies of Tcwl in northern Bryce Canyon National Park appears identical to similar multi-hued slopes mapped as Tcwl on the southwest flank of the Sevier Plateau by Biek et al. (2015).

Tcp **Claron Formation, pink member** (Eocene to Paleocene?) – Orangish-red, reddish-brown, and light-blue-gray limestone, mudstone, siltstone, sandstone, and conglomerate; locally mottled; oncolitic beds are common; limestone is poorly bedded, microcrystalline, and sandy, with 2% to 20% fine-grained quartz sand and is locally argillaceous; contains common calcite veinlets, calcite spar-filled vugs, calcite spar- and micrite-filled burrows, and stylolites; contains sparse small bivalves and planispiral gastropods; many limestone beds are calcic paleosols (Mullett et al., 1988a, 1988b; Mullett, 1989; Mullett and Wells, 1990); sandstone is thick-bedded, fine- to coarse-grained, calcareous, locally cross-bedded quartz arenite; mudstone is generally reddish-orange, silty, calcareous, contains calcareous nodules, and weathers to earthy, steep slopes between ledges of sandstone and limestone; pebbly conglomerate forms lenticular beds typically 5 to 15 feet (2–5 m) thick, containing rounded quartzite, limestone, and chert pebbles and cobbles; a basal conglomerate, up to 40 feet (12 m) thick is locally present (Gregory, 1951; Bowers, 1991); upper conformable contact corresponds to a pronounced color change from reddish-orange strata below to white to very pale orange strata above; map relations indicate Tcp is at least 700 feet (210 m) thick in the map area.

unconformity

CRETACEOUS

Kkl Kaiparowits Formation, lower unit (Late Cretaceous, late Campanian) – Yellowish-brown, fine-grained sandstone and varicolored and mottled, reddish-brown, purplish-gray, and gray mudstone; mapped below the pink member of the Claron Formation (Tcp) north of Johnson Bench, near the western map boundary; forms ledgy slopes; deposited as an eastward-prograding clastic wedge in a wet, subhumid alluvial plain with periodic to seasonal aridity near the western margin of the Late Cretaceous Western Interior Seaway (Roberts, 2007; Roberts et al., 2013); upper unconformable contact placed at the base of the first sandy limestone bed (calicic paleosol) or pebble to cobble conglomerate of the pink member of the Claron Formation; incomplete section is about 100 feet (30 m) thick in the map area.

Although undated and lacking badland-forming, bluish-gray mudstone and sandstone that typically characterize the Kaiparowits Formation, Biek et al. (2015) correlated Kkl to lithologically similar strata near the base of the formation on the west flank of the Kaiparowits Plateau (Eaton, 1991). Welle (2008) and Lawton and Bradford (2011) showed that the lower unit of the Kaiparowits Formation in the Kaiparowits basin has a different detrital zircon signature than its middle and upper units, characterized by more thrust-belt-derived grains, recording a transition in sediment source areas from the thrust-belt-sourced capping sandstone to arc-derived Kaiparowits.

Unconformity

Wahweap Formation (Late Cretaceous, early to middle Campanian) – Eaton (1991) divided the formation into four informal members in the Kaiparowits basin based principally on sandstone-to-mudstone ratios and fluvial architecture. In ascending order, these include the lower, middle, upper, and capping sandstone members. Beveridge et al. (2022) formalized these as the Last Chance Creek, Reynolds Point, Coyote Point, and Pardner Canyon Members, respectively. However, they advised that high-precision geochronology would be necessary to establish correlations beyond the Kaiparowits basin. Due to extensive vegetative cover and poor geomorphic expression in this map area, we map Eaton's lower three members simply as Wahweap Formation, undivided (Kw), and separate only the distinctive capping sandstone (Kwcs).

The Wahweap Formation is mostly fine grained sandstone, siltstone, and mudstone deposited in braided and meandering river and floodplain environments of a coastal plain (Tilton, 1991; Pollock, 1999; Lawton et al., 2003; Jinnah and Roberts, 2011). Detrital zircon and provenance studies of Eaton's (1991) lower three members show that these rivers flowed longitudinally to the foreland basin and tapped sources in the Cordilleran magmatic arc in southern California or western Nevada and the Mogollon Highlands of southern Arizona. In contrast, the capping sandstone member was deposited by transverse streams that tapped Mesozoic quartzose sandstones in the Sevier orogenic belt (Pollock, 1999; Lawton et al., 2003; Eaton, 2006; Jinnah et al., 2009). Thus, the basal contact of the capping sandstone member represents an abrupt change in sediment source that controls color, petrology, grain size, and fluvial style, documenting a major shift in depositional environments from meandering to braided rivers, and in source areas from arc to orogenic belt. The Wahweap contains a diverse fossil assemblage (see Tran et al., 2024, for a summary of fossils found within and near Bryce Canyon National Park); Jinnah (2013; see also Jinnah et al., 2009) reported an $^{40}\text{Ar}/^{39}\text{Ar}$ age of 80.6 ± 0.3 Ma (Campanian) on a devitrified volcanic ash located about 130 feet (40 m) above the base of the Wahweap Formation on the Kaiparowits Plateau and further noted that the formation was deposited between about 81 and 77 Ma. Beveridge et al. (2022) reported a new chronostratigraphic framework that places the lower and upper formation boundaries at $82.17 \pm 1.47/-0.63$ Ma and $77.29 \pm 0.72/-0.62$ Ma, respectively, thus constraining its age to the first half of the Campanian.

Kwcs Wahweap Formation, capping sandstone member (Late Cretaceous, middle Campanian) – White to very pale orange, locally iron stained, mostly medium-grained, trough cross-bedded quartz arenite; unit “caps” the lower mudstone-rich members of the Wahweap Formation; upper part contains abundant pebble stringers and conglomeratic beds with rounded quartzite, dolomite, chert, and limestone clasts; clasts are typically about 1 inch (2.5 cm) in diameter but as large as 2 to 3 inches (5–7.5 cm), and include common reddish-brown and purple quartzite clasts, unlike underlying Drip Tank strata; quartz grains are typically well rounded and commonly frosted, recycled from Mesozoic eolianites (Pollock, 1999; Lawton et al., 2003; see also UGS and AtoZ, 2013); locally contains carbonized or petrified plant debris, small mudstone rip-up clasts, iron concretions, and soft-sediment deformation features; typically poorly cemented, forming distinctive white, manzanita-covered slope-and-bench topography; named the Pardner Canyon Member by Beveridge et al. (2022) in the Kaiparowits Plateau; about 20 feet (6 m) exposed at a single outcrop mapped on northern Johnson Bench, but is absent near the Pink Cliffs where it has been removed by pre-Claron erosion.

Kw Wahweap Formation, upper, middle, and lower members, undivided (Late Cretaceous, early to middle Campanian) – Varicolored and mottled mudstone of brown, gray, reddish-brown, and pinkish hues, and lenticular beds of yellowish-brown fine-grained sandstone and silty sandstone; weathers to form ledgy slopes; hosts many landslides, including the historical State Route 12 landslide that has repeatedly damaged the highway near the head of Tropic Canyon (Knudsen, 2026); the sub-Claron unconformity cuts out varying amounts of the Wahweap, and thus thickness ranges from about 250 to 500 feet (75–150 m) in the map area.

Straight Cliffs Formation (Late Cretaceous, early Campanian to Turonian) –

Peterson (1969) divided the Straight Cliffs Formation into four members in the Kaiparowits Basin, in descending stratigraphic order: the Drip Tank, John Henry, Smoky Hollow, and Tibbet Canyon Members, and we follow that convention here, although only the Drip Tank and John Henry Members crop out in the map area. The Straight Cliffs Formation is an overall regressive sequence that formed during the last marine incursion of the Late Cretaceous Western Interior Seaway (e.g., Eaton et al., 2001; Moore and Straub, 2001; Tibert et al., 2003). The John Henry and Drip Tank Members were deposited in fluvial and floodplain environments of a coastal plain (Peterson, 1969; Eaton et al., 2001). The Straight Cliffs Formation contains a diverse fossil assemblage (see Tran et al., 2024, for a summary of fossils found within and near Bryce Canyon National Park). Detrital zircon studies of Szwarc et al. (2015) showed that the majority of zircons in fluvial strata were derived from the Mogollon Highlands of central Arizona, with subordinate contributions delivered from the Sevier fold-and-thrust belt and Cordilleran magmatic arc of southern California and adjacent Arizona via a northeast-flowing axial river system that flowed parallel to the fold and thrust belt.

Ksd Straight Cliffs Formation, Drip Tank Member (Late Cretaceous, early Campanian) – White to light-gray, fine- to medium-grained quartzose sandstone, and, in the upper part of the unit, pebbly sandstone and pebbly conglomerate; very thick bedded with prominent cross-stratification; clasts are subrounded to rounded, white and gray quartzite, gray Paleozoic limestone, and black chert, but lack the abundant reddish-brown and purple quartzite clasts found in the capping sandstone member of the Wahweap Formation; locally iron stained and contains casts of tree limbs; lower sandstone forms distinctive, manzanita-covered slopes and saddles, but upper part of unit tends to form cliffs and ledges; upper contact with the Wahweap Formation appears to be conformable and corresponds to the top of a white sandstone and pebbly sandstone, above which is yellowish-brown, fine-grained sandstone and lesser interbedded, varicolored and mottled mudstone of brown, gray, reddish-brown, and pinkish hues; recent chronostratigraphic studies (based on new U-Pb zircon ages) on the Wahweap Formation in the Kaiparowits Plateau by Beveridge et al. (2022) placed the lower boundary of the Wahweap with the Drip Tank Member at about 82 Ma, providing a minimum age for Drip Tank strata; thickness ranges from about 100 feet (30 m) north of Tropic Canyon to at least 160 feet (50 m) at the southeast corner of the map area.

unconformity

Ksj Straight Cliffs Formation, John Henry Member (Late Cretaceous, Santonian to late Turonian) – Yellowish- to reddish-brown, fine- to medium-grained, subarkosic sandstone and siltstone, and interbedded, locally mottled, gray, brown, and reddish-brown mudstone; forms ledgy slopes; sandstone is commonly bioturbated and locally stained by iron-manganese oxides; stacked or amalgamated sandstone beds make up most of the upper part of the unit; upper unconformable contact corresponds to a break in slope at the base of the Drip Tank Member; woody material and leaf impressions are locally abundant; Chentnik et al. (2015) identified four regressive-transgressive cycles within the member on the Kaiparowits Plateau and Benhallam et al. (2016) noted that the member provides an ~6-million-year record of coastal-plain to marginal-marine deposition; Szwarc et al. (2015) reported a maximum depositional age for the member of 82.8 ± 4.1 Ma; thickness about 800 to 1000 feet (250–300 m) in the Bryce Canyon quadrangle.

Subsurface Units

Ksjc Straight Cliffs Formation, John Henry Member, calico bed – Cross section only; thickness (150 feet [45 m]) from Knudsen et al. (in preparation).

Kss Straight Cliffs Formation, Smoky Hollow Member – Cross section only; thickness (125 to 200 feet [40–60 m]) from Knudsen et al. (in preparation).

- Kst** **Straight Cliffs Formation, Tibbet Canyon Member** – Cross section only; thickness (40 to 50 feet [12–15 m]) from Knudsen et al. (in preparation).
- Kt** **Tropic Shale** – Cross section only; thickness (700 to 1000 feet [215–300 m]) from Knudsen et al. (in preparation).
- Kn** **Naturita Formation** – Cross section only; thickness (150 to 250 feet [45–75 m]) from Knudsen et al. (in preparation).

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- Je** **Entrada Formation** – Cross section only; thickness (470 to 680 feet [135–205 m]) from Knudsen et al. (in preparation).
- Jc** **Carmel Formation** – Cross section only; thickness (370 to 540 feet [115–165 m]) from Knudsen et al. (in preparation).
- Jn** **Navajo Sandstone** – Cross section only; thickness (1300 to 2200 feet [395–670 m]) from Doelling (2008).

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