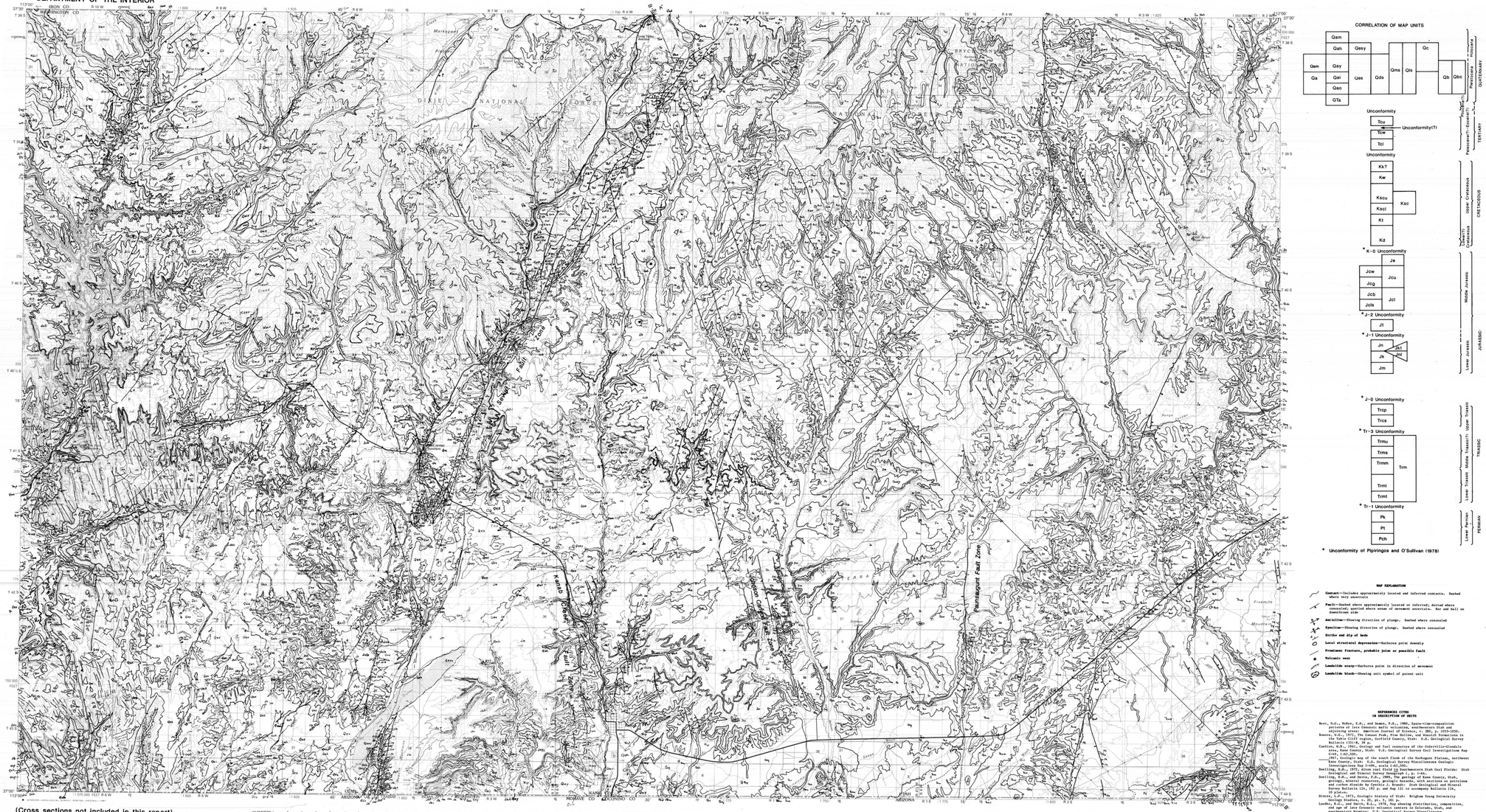
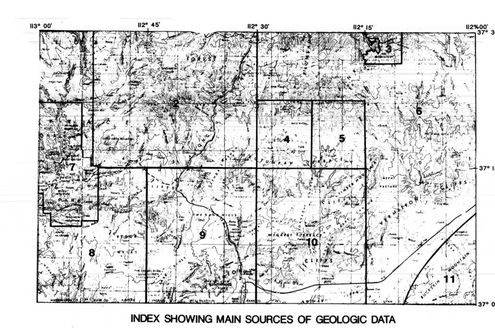
UNITED STATES GEOLOGICAL SURVEY
DEPARTMENT OF THE INTERIOR

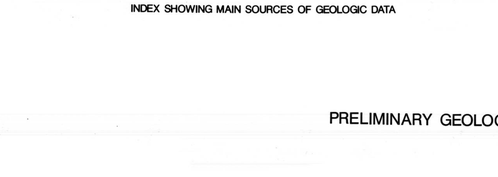
OPEN-FILE REPORT OF 90-542



(Cross sections not included in this report)



INDEX MAP SHOWING AREA OF THIS REPORT



INDEX SHOWING MAIN SOURCES OF GEOLOGIC DATA

CORRELATION OF MAP UNITS

* Unconformity of Pipirigos and O'Sullivan (1978)

DESCRIPTION OF MAP UNITS

ALLUVIAL DEPOSITS

Qam **Alluvium (Holocene)**—Unconsolidated deposits of locally derived sand, silt, clay, and minor gravel of modern flood plains and stream channels which normally dissected post-A.D. 1880 stream floors. Thickness much greater than 5 m (16 ft).

Qah **Alluvium (Holocene)**—Sand, silt, clay, and gravel of several cut-and-fill deposits dissected by post-A.D. 1880 arroyos. Radiocarbon ages from deposits along Park Wash and Ritchies Wash in Escalante Canyons indicate deposition beginning at 4,130±, 3,600±,390±, 4,190±, 2,240±, and 240 B.P.

Qay **Younger alluvium (Pleistocene)**—Mostly to moderately consolidated deposits of gravel, gravelly sand, and sandy silt. Forms low terraces 5-10 m (16-33 ft) topographically higher than unit Qah. Thickness 5-20 m (16-65 ft).

Qai **Intermediate alluvium (Pleistocene)**—Moderately consolidated deposits of gravel, gravelly sand, and sandy silt. Forms a dissected terrace 10-20 m (33-65 ft) topographically higher than unit Qay. Thickness 5-20 m (16-65 ft).

Qao **Older alluvium (Pleistocene)**—Firmly consolidated deposits of gravel, gravelly sand, and sandy silt. Forms a moderately dissected terrace not perceptibly higher than Qai. Thickness 10-30 m (30-165 ft).

QTa **Alluvium undivided (Pleistocene)**—Generally firmly consolidated sand and gravel. Occurs in terraces and pediments nearly west of the Hurricane Fault. Forms a dissected terrace 30 m (100 ft) or more higher than Qao. Sometimes basalt along Sam Pick of Virgin River.

Qes **Alluvium (Pleistocene); Pleistocene(?)**—Firmly consolidated gravel and sandy silt. Forms a dissected terrace 30 m (100 ft) or more above quaternary and silicified limestone. Occurs west of Devils Fault zone at altitudes comparable to unit Qes. Age uncertain.

EOLIAN DEPOSITS

Qsay **Eolian sand in active dunes (Holocene)**—Light-gray, yellowish-gray, and reddish-orange fine to medium well sorted sand composed mostly of quartz. Dunes are active and have no vegetation.

Qdo **Eolian sand in mostly inactive dunes (Holocene and Pleistocene)**—Sand as above, mostly reddish-orange; in mostly vegetation-covered dunes. Age is A.D. 1880 to 10,000 B.P. Includes sand that fills basins and moves, and in small dune fields on or in inclined areas; largely derived from Navajo Sandstone. May be as much as 15 m (50 ft) thick in places. Includes gently sloping areas modified by sheet wash.

Qes **Eolian sand (Pleistocene)**—Sand as in unit Qesy, in stabilized, mostly stabilized dunes and in fillings of topographically low areas. Locally includes small bedrock areas. Thickness much greater than 5 m (16 ft). Includes silt and sand residuum. Areas of mixed eolian and residual sand not everywhere shown in eastern part of quadrangle.

MASS WASTING DEPOSITS

Qc **Colluvium undivided (Holocene and Pleistocene)**—Poorly sorted debris flow, talus, and rockfall deposits of sand and angular to subangular rock fragments. Thickness much greater than 5 m (16 ft) in slope wasts, and small landslide deposits. Includes clayey weathering residuum and slope wash in some areas, such as west of Escalante Canyons and in Kanab Creek area.

Qls **Landslide slump-block deposits (Holocene and Pleistocene)**—Essentially coherent slumped and rotated blocks of bedrock, such as Triassic Moenkopi, dissolving in incompetent units such as the Jurassic Navajo and the Chinle Formation, the Entrada Sandstone, and Tropic Shale, and Cretaceous Dakota Sandstone, and Tropic Shale, which has been eroded and thus differentiated from unit Qmls.

Qms **Mass landslide about deposits (Holocene and Pleistocene)**—Large, coherent masses of Triassic Moenkopi and Chinle Formations, locally exhibiting landslide scarps, sag areas, and downslope creep surface contorts. Thickness largely unknown due to poor exposure, but may be as much as 25 m (80 ft) thick. Includes Bridgeland, and part of Bryce Canyon, transparent units, notably the Tropic Shale, Dakota, and Chinle Formations, and other unmapped areas of alluvial, pond, slope-wash deposits, and surface slump material

IGNEOUS ROCKS

Qb **Olivine basalt (Pleistocene)**—Extrusive basalt and basaltic cinders on Ninety Levs and cinder cones. Includes downslope concentrations of blocks that may be flow margins or talus. Minor basalt dikes on local features. Basalt, medium to darkgray, dense to vesicular; contains phenocrysts and groundmass of olivine, augite, and calcic plagioclase; groundmass also contains titanium oxides. Flows contain topographic benches and do not along pressure ridges valleys. Cinder cones and vents (Qbc) are composed of black to red, coarse to fine scoria and lapilli and bombs. Radiometric age of basalt flows thought to be younger than basalts in western part of quadrangle are 0.36, 0.34, and 0.8 Ma (Best and others, 1980)

SEDIMENTARY ROCKS

Trcp **Claron Formation (Lower Tertiary)**—Formerly the "Pink Cliffs", Pink Cliffs Member of the Wasatch Formation of Gregory (1950). Previously referred to as Wasatch Formation (Gardner, 1941) or Cedar Breaks Formation (Stokes, 1973) within the quadrangle or in the Cedar Breaks National Monument. Thickness may be as ~11,300 (?) ft. Age is Paleocene; regional unconformity.

Trcs **Claron Formation (Lower Tertiary)**—Sandstone, mostly quartzose, very light to light-gray, pink-orange, yellowish-gray, and reddish-orange, fine- to medium grained, well-sorted, thick-bedded to massive, cross-bedded, friable, porous, and very thick; contains local conglomerate and nonclinical beds; generally weakly cemented by ferruginous, siliceous, and calcareous cements. Forms cliffs, hoodoos, and pillars in spectacular erosional landscapes. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Trcs **Claron Formation (Lower Tertiary)**—Limestone, silt, clay, and minor sandstone. Contains abundant limestone pebbles and cobbles. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Trmu **Upper unit**—Sandstone, conglomerate, limestone, shale, and clay. Mostly slope forming, weathers drab gray and brown; locally contains abundant petrified wood. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Trms **Sandstone member (Lower Eocene)**—Sandstone, mostly quartzose, very light to light-gray, pink-orange, yellowish-gray, and reddish-orange, fine- to medium grained, well-sorted, thick-bedded to massive, cross-bedded, friable, porous, and very thick; contains local conglomerate and nonclinical beds; generally weakly cemented by ferruginous, siliceous, and calcareous cements. Forms cliffs, hoodoos, and pillars in spectacular erosional landscapes. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Trmn **Limestone member (Lower Eocene)**—Limestone, silt, clay, and minor sandstone. Contains abundant limestone pebbles and cobbles. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Trm **Wasatch Formation (Lower Eocene)**—Sandstone, with lesser shale, limestone, and conglomerate, siltstone, limestone breccia, and dolomite; mostly pink to pale pink to orange and light to very light gray; medium bedded to massive and poorly defined in carbonate rocks which exhibit mottled to nodular bedding; cross-bedded in part; friable to hard; ledge-forming. Contains sparse to some beds, locally abundant very rare casts and molds of gastropods and pelecypods. Well-rounded pebbles and cobbles of quartzite, chert, and limestone common in conglomerate and conglomerate beds exposed in eastern parts of quadrangle such as Bryce Canyon area. Locally weathers to spectacular cliffs, hoodoos, and spires. Uppermost beds are characterized by a bed of reddish-orange claystone and siltstone about 10 m (30 ft) thick. Thickness 0 m (0 ft) in western part of Sevier Fault zone but beds were mapped in Sanders (1967) in places as the "uppermost prominent light-gray ledge-forming member" of the Wasatch Formation. Thickness 0 m (0 ft) in the described sections. Basal beds, 8 to about 30 m (20-50 ft) thick, consist of yellowish-orange-weathering shale, claystone, and siltstone, and pink to light-gray limestone. Thickness about 0 m (0 ft) in eastern part of quadrangle to about 350 m (1,000 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Tcl **Limestone member (Lower Eocene)**—Limestone, silt, clay, and minor sandstone. Contains abundant limestone pebbles and cobbles. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Tcu **Claron Formation (Lower Tertiary)**—Sandstone, mostly quartzose, very light to light-gray, pink-orange, yellowish-gray, and reddish-orange, fine- to medium grained, well-sorted, thick-bedded to massive, cross-bedded, friable, porous, and very thick; contains local conglomerate and nonclinical beds; generally weakly cemented by ferruginous, siliceous, and calcareous cements. Forms cliffs, hoodoos, and pillars in spectacular erosional landscapes. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Tcs **Claron Formation (Lower Tertiary)**—Limestone, silt, clay, and minor sandstone. Contains abundant limestone pebbles and cobbles. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Tcl **Limestone member (Lower Eocene)**—Limestone, silt, clay, and minor sandstone. Contains abundant limestone pebbles and cobbles. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Ks **Sanpitch(?) Formation (Upper Cretaceous)**—Sandstone, clay, mudstone, minor tuffaceous tuffaceous sandstone and limestone-clast conglomerate. Sandstone, subarkose to litharenite, drab yellowish-gray and yellowish-orange, medium to very coarse grained, subangular to subrounded, poorly sorted, and clay matrix; weathers brownish gray with earthy hues. Conglomerate, pebbles and cobbles of quartzite, chert, and crystalline limestone; lesser amounts of the underlying Mesozoic strata. Clay and mudstone mostly medium- to dark-gray, in part carbonaceous, with few paleosol beds. Unit contains scattered vertebrate (probably dinosaur) bones, poorly preserved pelecypod shells, and plant fragments. Basal contact is a disconformity or paraconformity with underlying Jurassic Navajo Sandstone. Estimated thickness 0 m (0 ft) to about 75 m (250 ft); absent or intermittently present in vicinity of and east of Sevier fault zone. Depositional environment: upper(?) alluvial plain

Ev **Voknaq Formation (Upper Cretaceous)**—Slope- and ledge-forming shale, clay, siltstone, and sandstone; minor conversionary limestone, carbonaceous shale, silty limestone, and claystone. Shale, mudstone, and claystone, mostly medium- to dark-gray and pale red, relatively high clay mineral content; sandstone about 10-25 percent, mostly in lower part; mostly fine grained, well sorted, thin bedded, subarkosic, locally tuffaceous, commonly weathers to vivid pelmatch orange hues; mostly well indurated but less indurated and coarser grained in upper part; sandstone beds 1 to 3 (10 ft) thick but as much as 15 m (50 ft) thick; tuffaceous channel fill sandstone tongues and sheet sandstone beds in upper part. Basal contact is a disconformity. Formation contains sparse freshwater pelecypods and gastropods and limnostic wood fragments. Basal contact drawn on top of lowest bed of dark-gray to black shale or claystone. Thickness 0 m (0 ft) to about 100-200 m (300-660 ft) east of Sevier fault zone and south of Bryce Canyon National Park. Thickness 0 m (0 ft) in southwestern part of quadrangle. Depositional environment: upper(?) alluvial plain

Ksc **Straight Cliffs Formation, upper unit (Upper Cretaceous)**—Sandstone and lesser shale, claystone, and siltstone; sandstone, mostly medium- to fine-grained, well-sorted, thick-bedded to massive, cross-bedded, friable, and very thick; contains abundant petrified wood. Shale and claystone, mostly medium- to dark-gray, in part carbonaceous, with few paleosol beds. Unit contains scattered vertebrate (probably dinosaur) bones, poorly preserved pelecypod shells, and plant fragments. Basal contact is a disconformity or paraconformity with underlying Jurassic Navajo Sandstone. Estimated thickness 0 m (absent) to about 75 m (250 ft); absent or intermittently present in vicinity of and east of Sevier fault zone. Depositional environment: upper(?) alluvial plain

Ksl **Straight Cliffs Formation, lower unit (Upper Cretaceous)**—Sandstone, mostly medium- to fine-grained, well-sorted, thick-bedded to massive, cross-bedded, friable, and very thick; contains abundant petrified wood. Shale and claystone, mostly medium- to dark-gray, in part carbonaceous, with few paleosol beds. Unit contains scattered vertebrate (probably dinosaur) bones, poorly preserved pelecypod shells, and plant fragments. Basal contact is a disconformity or paraconformity with underlying Jurassic Navajo Sandstone. Estimated thickness 0 m (absent) to about 75 m (250 ft); absent or intermittently present in vicinity of and east of Sevier fault zone. Depositional environment: upper(?) alluvial plain

Tcu **Tropic Shale (Lower Cretaceous)**—Shale, mostly medium- to dark-gray, in part carbonaceous, with few paleosol beds. Unit contains scattered vertebrate (probably dinosaur) bones, poorly preserved pelecypod shells, and plant fragments. Basal contact is a disconformity or paraconformity with underlying Jurassic Navajo Sandstone. Estimated thickness 0 m (absent) to about 75 m (250 ft); absent or intermittently present in vicinity of and east of Sevier fault zone. Depositional environment: upper(?) alluvial plain

Jn **Navajo Sandstone (Middle Jurassic)**—Sandstone, mostly quartzose, very light to light-gray, pink-orange, yellowish-gray, and reddish-orange, fine- to medium grained, well-sorted, thick-bedded to massive, cross-bedded, friable, porous, and very thick; contains local conglomerate and nonclinical beds; generally weakly cemented by ferruginous, siliceous, and calcareous cements. Forms cliffs, hoodoos, and pillars in spectacular erosional landscapes. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Js1 **Kayenta Formation, main part (Lower Jurassic)**—Siltstone and sandstone, mostly medium- to dark-gray and brownish-gray, in part carbonaceous, with few paleosol beds. Unit contains scattered vertebrate (probably dinosaur) bones, poorly preserved pelecypod shells, and plant fragments. Basal contact is a disconformity or paraconformity with underlying Triassic Moenkopi and Chinle Formations. Estimated thickness 0 m (absent) to about 75 m (250 ft); absent or intermittently present in vicinity of and east of Sevier fault zone. Depositional environment: upper(?) alluvial plain

Js2 **Kayenta Formation, lower part (Lower Jurassic)**—Siltstone and sandstone, mostly medium- to dark-gray and brownish-gray, in part carbonaceous, with few paleosol beds. Unit contains scattered vertebrate (probably dinosaur) bones, poorly preserved pelecypod shells, and plant fragments. Basal contact is a disconformity or paraconformity with underlying Triassic Moenkopi and Chinle Formations. Estimated thickness 0 m (absent) to about 75 m (250 ft); absent or intermittently present in vicinity of and east of Sevier fault zone. Depositional environment: upper(?) alluvial plain

Jd **Dakota Formation (Upper and Lower? Cretaceous)**—Slope- to ledge-forming interbedded sandstone, claystone, sandstone, carbonaceous mudstone, and minor but distinctive bentonitic mudstone, coal, and limestone. Sandstone, subarkose to litharenite, drab yellowish-gray, brown, and light-gray, medium- to very coarse grained, subangular to subrounded, poorly sorted, and clay matrix; weathers brownish gray with earthy hues. Conglomerate, pebbles and cobbles of quartzite, chert, and crystalline limestone; lesser amounts of the underlying Mesozoic strata. Clay and mudstone mostly medium- to dark-gray, in part carbonaceous, with few paleosol beds. Unit contains scattered vertebrate (probably dinosaur) bones, poorly preserved pelecypod shells, and plant fragments. Basal contact is a disconformity or paraconformity with underlying Jurassic Navajo Sandstone. Estimated thickness 0 m (absent) to about 75 m (250 ft); absent or intermittently present in vicinity of and east of Sevier fault zone. Depositional environment: upper(?) alluvial plain

Pk **Kaibab Limestone (Permian)**—Best exposed in Kaibab Gulch. Upper part is ledge- and slope-forming and consists of yellowish-gray limestone, dolomitic limestone, dolomite, sandstone, and banded chert. Lower part is cliff-forming and consists of light-gray to white limestone and sandstone. Cherts, brachiopods, bryozoans, and crinoids common in some limestone beds. This unit includes the Toroweap Formation of Gregory (1950) and the Fort Pearce Sandstone member of Stokes (1961). Thickness 0 m (absent) to about 150 m (500 ft). Age is Permian. Deposited in marine, upper part marginal shallow restricted marine and bay or lagoonal; lower part open marine.

Pt **Toroweap Formation (Lower Permian)**—Exposed in Kaibab Gulch. Upper part is cliff-forming and consists of light-gray limestone (70 percent), sandstone breccia (20 percent), gray sandstone to crystalline limestone (less than 10 percent) and minor red shale and siltstone. Lower part is slope-forming and consists of pale-red siltstone (70 percent), with minor interbedded gray crystalline limestone, shale, chert, and chert conglomerate; sandstone is fine grained, well sorted, and thin bedded to massive and cross stratified; limestone is in part fossiliferous. Unit is cliff-forming, about 20 m (65 ft) thick. Underlying Moenkopi Shale mostly reddish-brown sandstone, mudstone, and shale with minor gypsum stringers; sandstone and mudstone exhibit ripple marks, mudcracks, and salt casts. Unconformity covers lower part; incomplete exposed thickness 0 m (absent) to about 17 m (55 ft). Depositional environments: eolian dune field and arid coastal plain to marginal marine

Pch **Coconino Sandstone and Hermit Shale undivided (Lower Permian)**—Exposed in Kaibab Gulch. Coconino Sandstone mostly light-gray and yellowish-gray, fine grained, well sorted, thick bedded to massive (70 percent), with minor interbedded gray crystalline limestone, shale, chert, and chert conglomerate; sandstone is fine grained, well sorted, and thin bedded to massive and cross stratified; limestone is in part fossiliferous. Unit is cliff-forming, about 20 m (65 ft) thick. Underlying Hermit Shale mostly reddish-brown sandstone, mudstone, and shale with minor gypsum stringers; sandstone and mudstone exhibit ripple marks, mudcracks, and salt casts. Unconformity covers lower part; incomplete exposed thickness 0 m (absent) to about 17 m (55 ft). Depositional environments: eolian dune field and arid coastal plain to marginal marine

Js **Entrada Sandstone (Middle Jurassic)**—Ledge-forming sandstone and minor interbedded siltstone and claystone. Sandstone, mostly light- to medium-light-gray, fine- to medium-grained, quartzose, round to subround, moderately indurated, with calcareous, siliceous, and ferruginous cements; weathers pale red. Forms cliffs and hoodoos in pioneer crosbeds. Thickness about 30 m (100 ft) in eastern part of exposure belt in northeastern part of quadrangle; thins westward to about 0 m (absent) at the beginning of Sevier Fault zone. Contains petrified wood in some field localities. Age is Middle Jurassic. Depositional environments probably alluvial coastal plain to marginal marine.

Jcw **Carmel Formation (Middle Jurassic)**—Consists of four members; contacts between members appear to be conformable; base of lowermost member is a disconformity or paraconformity with top of Sullivan Canyon Member; see text for description of units.

Jcu **Winsor Member**—Mostly sandstone, fine- to medium-grained, friable; weathers to vivid pelmatch orange hues. Thickness about 0 m (absent) to about 100 m (300 ft). Contains light-gray to yellowish-gray sandstone, steep slopes to cliff-forming, crossbedded; lower part reddish brown to light brown, slope forming. Member thins westward, mostly resulting from pre-Carmel erosional truncation; absent in vicinity of Sevier fault, northeastern part of quadrangle. Thickness 0 m (absent) to about 90 m (300 ft). Age is Middle Jurassic. Deposited in marine, upper part marginal shallow restricted marine and bay or lagoonal.

Jcg **Crystal Creek member of Thompson and Stokes (1970)**—Significant sandstone, siltstone, and mudstone, reddish brown, light-brown, and light-gray; interbedded with clay-gall conglomerate. Thickness about 0 m (absent) to about 100 m (300 ft) to 200-m (700-ft). Depositional environments: lower coastal plain and subtidal

Jcb **Banded member (Crystal Creek member of Thompson and Stokes (1970))**—Significant sandstone, siltstone, and mudstone, reddish brown, light-brown, and light-gray; interbedded with clay-gall conglomerate. Thickness about 0 m (absent) to about 100 m (300 ft) to 200-m (700-ft). Depositional environments: lower coastal plain and subtidal

Jcls **Limestone member of Sellers and Sorenson (1969) of Doelling and Davis, 1989)**—Mostly limestone and calcareous shale, minor sandstone, dolomitic limestone, dolomite and local minor gypsum; yellowish-gray, light-gray, and light-brown; cliff-forming, gray, and limestone mostly marine; in part oolitic, pisolitic, and oncolitic, in part sandy, in part carbonaceous, and conglomerate with limestone clasts. Thickness about 0 m (absent) to about 100 m (300 ft). Age is Middle Jurassic. Deposited in lagoon or bay and low tidal flat

Jcl **Carmel Formation, upper unit**—Sandstone in discontinuous part of quadrangle. Slope-forming, light-red, fine-grained, friable sandstone. Contains petrified wood. Thickness about 0 m (absent) and Winsor Members of Carmel Formation which lies conformably below Sevier Fault zone. Age is Middle Jurassic. Deposited in marine, upper part marginal shallow restricted marine and bay or lagoonal. Pipirigos, 1979, suggests that unit includes beds equivalent to nearly cliff-forming quartzose varicgated sandstone, fine- to medium-grained, well-sorted, thick-bedded to massive, cross-bedded, friable, porous, and very thick; contains petrified wood. Thickness about 0-6 m (0-20 ft), pinches out west of Paroussagunt fault zone. Total upper unit thickness about 0 m (absent) to about 100 m (300 ft). Age is Middle Jurassic. Deposited in marine, upper part marginal shallow restricted marine and bay or lagoonal.

Jcl **Carmel Formation, lower unit**—Sandstone in northeastern part of quadrangle. Sandstone, siltstone, mudstone, and limestone; slope- and ledge-forming, light-red, fine-grained, friable sandstone. Contains petrified wood. Thickness about 0 m (absent) to about 100 m (300 ft) to 200-m (700-ft). Depositional environments: lower coastal plain to marginal marine

Qb Qb **Olivine basalt (Pleistocene)**—Extrusive basalt and basaltic cinders on Ninety Levs and cinder cones. Includes downslope concentrations of blocks that may be flow margins or talus. Minor basalt dikes on local features. Basalt, medium to dark-gray, dense to vesicular; contains phenocrysts and groundmass of olivine, augite, and calcic plagioclase; groundmass also contains titanium oxides. Flows contain topographic benches and do not along pressure ridges valleys. Cinder cones and vents (Qbc) are composed of black to red, coarse to fine scoria and lapilli and bombs. Radiometric age of basalt flows thought to be younger than basalts in western part of quadrangle are 0.36, 0.34, and 0.8 Ma (Best and others, 1980)

Jn **Navajo Sandstone (Lower and Middle Jurassic)**—Sandstone, highly quartzose, very light to light-gray, pink-orange, yellowish-gray, and reddish-orange, fine- to medium grained, well-sorted, thick-bedded to massive, cross-bedded, friable, porous, and very thick; contains local conglomerate and nonclinical beds; generally weakly cemented by ferruginous, siliceous, and calcareous cements. Forms cliffs, hoodoos, and pillars in spectacular erosional landscapes. Thickness about 0 m (0,400 ft) in eastern part to about 350 m (1,800 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Trc **White Limestone (Upper Triassic)**—Cliff- to steep slope-forming limestone and minor shale and shaly clay; white to very light gray, pink, and light-brown; weathers white and light gray; massive, rugs, oolitic, and pisolitic, and dolomitic calcarenites. Thickness about 20-40 m (60-120 ft)

Trl **Lower Member**—Sandstone, mostly fine grained, well sorted, thin bedded with some rough crossbeds; sandstone, limestone breccia, and dolomite; mostly pink to pale pink to orange and light to very light gray; bedding planes marked by poorly defined in carbonate rocks which exhibit mottled to nodular bedding; cross-bedded in part; friable to hard; ledge forming. Contains local concretions and molds of gastropods and pelecypods. Well-rounded pebbles and cobbles of quartzite, chert, and limestone common in conglomerate and conglomerate beds exposed in eastern parts of quadrangle such as Bryce Canyon area. Locally weathers to spectacular cliffs, hoodoos, and spires. Uppermost beds are characterized by a bed of reddish-orange claystone and siltstone about 10 m (30 ft) thick. Thickness 0 m (absent) to about 100 m (300 ft) thick and thinnest in vicinity of and east of Sevier fault zone but beds were mapped in Sanders (1967) in places as the "uppermost prominent light-gray ledge-forming member" of the Wasatch Formation. Thickness 0 m (0 ft) in the described sections. Basal beds, 8 to about 30 m (20-50 ft) thick, consist of yellowish-orange-weathering shale, claystone, and siltstone, and pink to light-gray limestone. Thickness about 0 m (absent) to about 20 m (60 ft) in eastern part of quadrangle to about 350 m (1,000 ft) along Paroussagunt Canyon near western edge of quadrangle. Contains abundant petrified wood in some field localities. Age is Paleocene and Eocene (?) based on fossil mammals. Deposited in lacustrine environment.

Pk **Kaibab Limestone (Permian)**—Best exposed in Kaibab Gulch. Upper part is ledge- and slope-forming and consists of yellowish-gray limestone, dolomitic limestone, dolomite, sandstone, and banded chert. Lower part is cliff-forming and consists of light-gray to white limestone and sandstone. Cherts, brachiopods, bryozoans, and crinoids common in some limestone beds. This unit includes the Toroweap Formation of Gregory (1950) and the Fort Pearce Sandstone member of Stokes (1961). Thickness 0 m (absent) to about 150 m (500 ft). Age is Permian. Deposited in marine, upper part marginal shallow restricted marine and bay or lagoonal; lower part open marine.

Pt **Toroweap Formation (Lower Permian)**—Exposed in Kaibab Gulch. Upper part is cliff-forming and consists of light-gray limestone (70 percent), sandstone breccia (20 percent), gray sandstone to crystalline limestone (less than 10 percent) and minor red shale and siltstone. Lower part is slope-forming and consists of pale-red siltstone (70 percent), with minor interbedded gray crystalline limestone, shale, chert, and chert conglomerate; sandstone is fine grained, well sorted, and thin bedded to massive and cross stratified; limestone is in part fossiliferous. Unit is cliff-forming, about 20 m (65 ft) thick. Underlying Hermit Shale mostly reddish-brown sandstone, mudstone, and shale with minor gypsum stringers; sandstone and mudstone exhibit ripple marks, mudcracks, and salt casts. Unconformity covers lower part; incomplete exposed thickness 0 m (absent) to about 17 m (55 ft). Depositional environments: eolian dune field and arid coastal plain to marginal marine

Pch **Coconino Sandstone and Hermit Shale undivided (Lower Permian)**—Exposed in Kaibab Gulch. Coconino Sandstone mostly light-gray and yellowish-gray, fine grained, well sorted, thick bedded to massive (70 percent), with minor interbedded gray crystalline limestone, shale, chert, and chert conglomerate; sandstone is fine grained, well sorted, and thin bedded to massive and cross crosbeds; limestone is in part fossiliferous. Unit is cliff-forming, about 20 m (65 ft) thick. Underlying Hermit Shale mostly reddish-brown sandstone, mudstone, and shale with minor gypsum stringers; sandstone and mudstone exhibit ripple marks, mudcracks, and salt casts. Unconformity covers lower part; incomplete exposed thickness 0 m (absent) to about 17 m (55 ft). Depositional environments: eolian dune field and arid coastal plain to marginal marine

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SOURCES OF GEOLOGIC DATA

Geology from the published and unpublished sources listed below has been in part modified and adjusted to fit the topographic base. Principal sources are given first. Amount of data used from additional sources, including theses, dissertations, unpublished maps, oil and gas studies, water studies, surveys and bore hole logs, is dependent on index.

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