Department of Environment and Natural Resources
Division of Financial and Technical Assistance
Geological Survey
7.5 Minute Series Geologic Quadrangle Map 10

Geologic Map of the Piedmont Quadrangle, South Dakota

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2009

State of South Dakota
M. Michael Rounds, Governor

South Dakota Geological Survey
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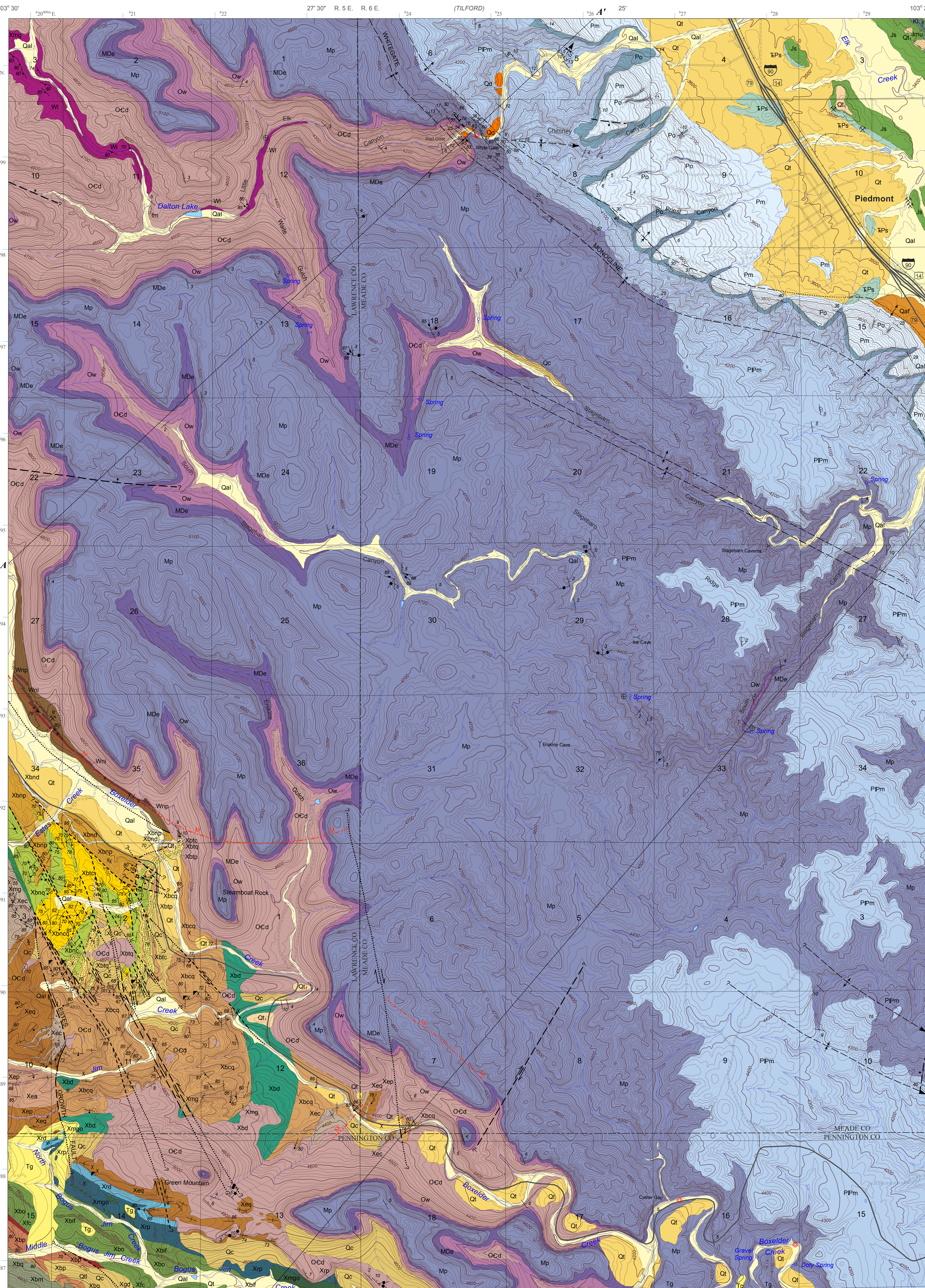
Prepared in cooperation with the South Dakota School of Mines and Technology



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Map base modified from U.S. Geological Survey 1:24,000-scale Piedmont digital line graph.
Projection is Universal Transverse Mercator, Zone 13.
Datum is 1983 North American.

SCALE 1:24,000

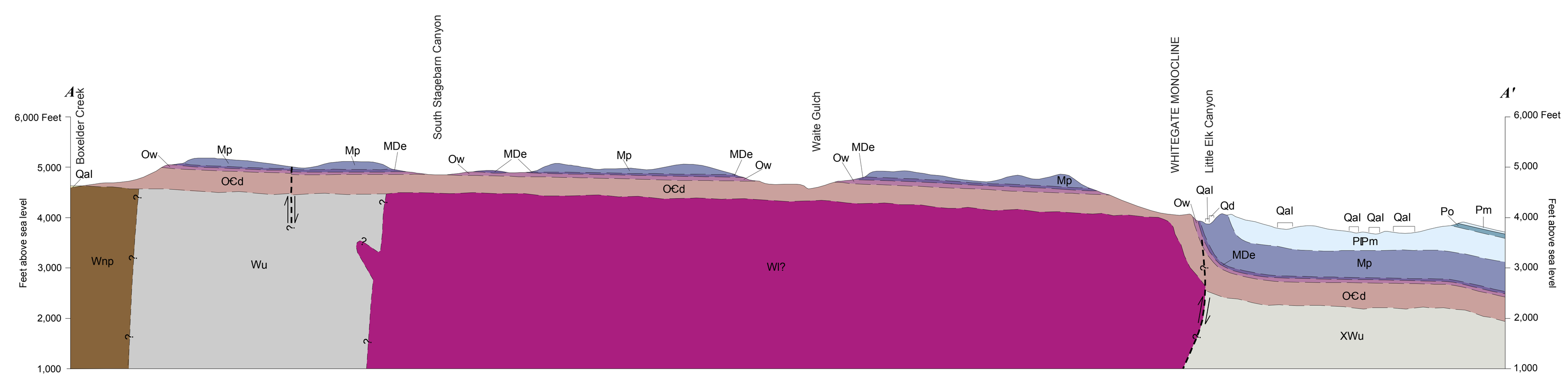
CONTOUR INTERVAL 20 FEET

NORTH

UTM GRID AND 1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

1° 05' 19 MILS — 13° 231 MILS

South Dakota — Quadrangle location



EXPLANATION

Quaternary

- **Qal — Alluvium -** Stream deposits of unconsolidated to loosely consolidated clay- to boulder-sized clasts. Indicated by brackets on cross section A-A' where too thin to show. Estimated thickness up to 35 ft (11 m)
- **Qc — Colluvium -** Unconsolidated debris deposited by gravity along steep slopes. Indicated by brackets on cross section B-B' where too thin to show. Estimated thickness up to 20 ft (6 m)
- **Qaf — Alluvial fan -** Unconsolidated to loosely consolidated, clay- to boulder-sized clasts. Located proximal to present-day drainages
- **Qtl — Talus -** Angular quartzite blocks derived from Xbq. Estimated thickness up to 33 ft (10 m)
- **Qt — Terrace deposit -** Unconsolidated clay- to boulder-sized clasts deposited along present-day drainages. Thickness up to 35 ft (11 m)
- **Qt_1 — Terrace deposit -** Clay- to boulder-sized clasts of older stream deposits. Approximately 40-50 ft (12-15 m) above present-day drainages
- **Qd — Debris flow deposit -** Composed of very large boulders within finer debris. Formed from breached dam(s) of landslides in lower Little Elk Canyon. Boulders have been washed onto terrace deposits near Interstate 90. Indicated by brackets on cross section A-A' where too thin to show. Thickness up to 40 ft (12 m)

Disconformity

Tertiary

- **Tg — Gravel deposit -** Generally gravel at surface; artificial exposures may disclose pinkish bentonitic beds at depth. Based on elevation, interpreted to be equivalent to known Oligocene White River deposits in other areas. Thickness up to 30 ft (9 m)

Unconformity

Cretaceous — Lower Cretaceous

- **Kl — Lakota Formation -** Sandstone; tan, thick-bedded. Only basal portion present. Exposed thickness 30-45 ft (9-14 m)

Disconformity

Jurassic — Upper Jurassic, Middle Jurassic

- **Jmu — Morrison Formation and Unkpapa Sandstone -** Greenish-gray bentonitic shale and sandstone, and beige to white, friable dune sandstone. Combined thickness 100-125 ft (30-38 m)
- **Js — Sundance Formation -** Greenish-gray shale, brownish-orange sandstone, and minor limestone; laminated to medium-bedded. Thickness 330-350 ft (101-107 m)

Disconformity

Triassic — Lower Triassic; **Permian** — Upper Permian, Lower Permian; **Pennsylvanian** — Upper Pennsylvanian

- **ꞦPs — Spearfish Formation -** Red siltstone, shale, and minor limestone and gypsum. May include the Gypsum Spring Formation at the top of the unit. Thickness 500-530 ft (152-162 m)
- **Pm — Minnekahta Limestone -** Pink to beige, thin-bedded limestone. Thin shale partings near the middle. Contains abundant stylolites. Thickness 36-42 ft (11-13 m)

Disconformity

- **Po — Opeche Shale -** Maroon to red shale and siltstone. Thickness 80-110 ft (24-34 m)
- **PIPm — Minnelusa Formation -** Brown, reddish, thin- to thick-bedded sandstone, limestone, and shale. Thickness 565-645 ft (172-197 m)

Disconformity

Mississippian — Lower Mississippian; **Devonian** — Upper Devonian

- **Mp — Pahasapa Limestone -** Beige to white, medium- to thick-bedded limestone and dolomite. Thickness 480-510 ft (146-155 m)
- **MDe — Englewood Limestone -** Mauve to pink, thin-bedded, finely crystalline shale, limestone, and dolomite. Thickness 36-55 ft (11-17 m)

Disconformity

Ordovician — Upper Ordovician

- **Ow — Winnipeg Formation -** Gray to green, laminated to thin-bedded shale. Thickness 10-80 ft (3-24 m). Exposures north of Little Elk Canyon may include up to 5 ft (1.5 m) of Whitewood Limestone

Disconformity

Cambrian — Lower Ordovician, Middle to Upper Cambrian

- **OЄd — Deadwood Formation -** Glauconitic sandstone, shale, limestone pebble conglomerate, and local basal conglomerate. Uppermost thick-bedded iron-stained sandstone from 55-90 ft (17-27 m) thick. Total thickness 350-425 ft (107-130 m)

Unconformity

Precambrian — Lower Proterozoic

- **Xmg — Metagabbro -** Sills and dikes, greenish-gray, medium-grained except where sheared or well foliated. It is uncertain that all bodies shown as Xmg are of the same age
- **Xmgo — Metagabbro (older) -** Sills and dikes of greenish, massive to schistose amphibolite. Sill 0.75 mi (1.2 km) southeast of Green Mountain has a Pb-Pb zircon age of 1,964+/-15 Ma (Redden and others, 1990) indicating a post Estes Formation emplacement. It is uncertain that all bodies shown as Xmgo are of the same age
- **Xbo, Xbif — Hay Creek Greenstone -** Xbo - Tholeiitic, generally pillowed greenstone and amphibolite. Xbif - Interflow intervals of phyllite and metachert. May be locally similar to carbonate-facies banded iron-formation. Only thicker intervals shown
- **Xfc — Ferruginous metachert -** Massive to thin-bedded, iron-stained metachert; typically interlayed with lenses of dark phyllite. Locally transitional to carbonate facies iron-formation
- **Xbp, Xbq, Xbm — Buck Mountain Quartzite -** Xbm - Phyllite and quartzite; thin- to thick-bedded, gray to olive-drab phyllite and tan to grayish to white quartzite; abundant ripple marks in metasiltstone protoliths. Xbq - Thick-bedded to massive quartzite subunits. Xbp - Dominantly thin-bedded greenish to gray phyllite with sparse quartzite. Protolith of the Buck Mountain Quartzite is a marine shelf deposit
- **Xgd — Gingrass Draw Slate -** Olive-drab to tan, thin-bedded slate. Contains quartzite and metasilt beds to the south in the Pactola Dam quadrangle and is very difficult to distinguish from parts of the Buck Mountain Quartzite. Chlorite-rich phyllite is likely reworked volcanic tuff
- **Xrd, Xrp — Roberts Draw Limestone -** Xrp - Greenish-gray to dark-gray phyllite; locally contains 5 to 25 percent dolomite. Some magnetite occurs where adjacent to carbonate rocks. Very sparse small stromatolites locally occur in the more pure dolomite units. Xrd - Recrystallized siliceous dolomite; typically thick-bedded and locally containing lenses of pebbly metaconglomerate and quartzite
- **Xea, Xeq, Xep, Xec — Estes Formation -** Xec - Metaconglomerate and impure quartzite. Cross pattern indicates areas containing clasts of banded iron-formation which postdates the Boxelder Creek Formation. Xeq - Quartzite; thin- to thick-bedded, gray, tan, grayish-white; may include gray phyllite and lenses of metaconglomerate. Xep - Gray phyllite. Xea - Arkosic quartzite and metagrit with local phyllite interbeds. Protolith is generally a marine fan deposit adjacent to growth faults. Approximately 2.10-2.02 Ga (Frei and others, 2008)

Unconformity

- **Xbd — Blue Draw Metagabbro -** Gravity differentiated sill consisting of a mafic lower cumulate zone (altered to serpentinite) and a metagabbro interior. An upper, thin granitic differentiate is exposed in the Nemo quadrangle where a Pb-Pb age of 2,480+/-6 Ma was obtained (Dahl and others, 2006). Separate small body of serpentinite along upper Jim Creek inferred to be correlative
- **Xbcq, Xbtq, Xbtc, Xbtp, Xbnp, Xbnq, Xbnd, Xbnc, Xbc — Boxelder Creek Quartzite; includes Novak and Tomahawk tongues -** Xbcq - Quartzite, grayish-white to tan. Thick-bedded with abundant small scale cross bedding indicative of a fluvial origin. Novak Tongue includes Xbnp, Xbnd, Xbncq, Xbnc, and Xbnq; Xbnp - Phyllite; greenish-gray; contains sparse quartzite and metachert clasts probably of Archean age which decrease in abundance to the north. Xbnd - Dolomite and minor gray phyllite. Xbncq - Metaparaconglomerate and quartzite. Abundant taconite clasts of hematite and metachert iron-formation typically decrease to the north and paraconglomerate interfingers with Xbnp. Xbnc - Metaconglomerate containing taconite clasts. Xbnq - Chloritic quartzite; locally has scattered pebbles and thin phyllite interbeds. Tomahawk Tongue includes Xbtq, Xbtc, and Xbtp: Xbtq - Quartzite and metagrit. Xbtc - Metaconglomerate and metagrit; typically a pyritiferous, uraniferous, and auriferous pebble conglomerate. Granules of blue quartz probably derived from the Little Elk Granite are common. Usually has chromite and fuchsite. Xbtp - Phyllite, gray to green, thin-bedded, poorly exposed. Protolith is an overbank deposit.
- **XWu — Undifferentiated Lower Proterozoic and Upper Archean rocks -** Shown only in cross sections

Disconformity

Upper Archean

- **Wnp, Wni, Wnp — Nemo Iron-Formation -** Wni - Thin-bedded metachert and hematite banded iron-formation. Locally consists of two or more subunits 15-56 ft (5-17 m) thick separated by similar thicknesses of thin-bedded greenish phyllite typically containing magnetite. Wnp - Green, thin- to medium-bedded phyllite; largely inferred but present in drill holes adjacent to Wni. No exposures known north of unit Wni. In fault contact with Proterozoic rocks but believed to be the source of banded iron-formation clasts in lower Boxelder Creek Quartzite. Approximately 2.9-2.6 Ga (Frei and others, 2008)

Unconformity?

- **Wl — Little Elk Granite -** Generally coarse-grained, foliated, I-type augen granite which locally contains blue quartz. U-Pb age 2,549+/-11 Ma (Gosselin and others, 1988)
- **Wu — Undifferentiated Upper Archean rocks -** Shown only in cross sections

Contact

Long dashed where approximately located; short dashed and queried where inferred on cross section; dotted where concealed

FAULTS

Fault — Long dashed where approximately located; short dashed were inferred; dotted where concealed; queried where uncertain. Bar and ball on downthrown side. Arrows indicate lateral movement. Tic indicates dip direction and amount. A (away) and T (toward) indicate relative movement on cross section. The Estes Fault is interpreted as a growth fault with erosion contemporaneous with faulting, influencing deposition of the Estes sediments to the west of the fault, and is characteristic of a rifting environment

FOLDS

- **Anticline** — Showing crest line and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed; queried where uncertain
- **Syncline** — Showing trough line and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed; queried where uncertain
- **Monocline, anticlinal bend** — Shorter arrow indicates steeper beds. Long dashed where approximately located; dotted where concealed
- **Monocline, synclinal bend** — Shorter arrow indicates steeper beds. Long dashed where approximately located; dotted where concealed
- **Minor fold** — Showing bearing and plunge

STRIKE AND DIP OF BEDDING

- Horizontal
- Inclined
- Inclined — Top direction of beds known to be in dip direction
- Vertical
- Vertical — Ball indicates top direction of beds
- Overturned — Top direction of beds known to be opposite dip direction
- Top of bed — Shown by sedimentary structures

STRIKE AND DIP OF FOLIATION

- Inclined
- Vertical

STRIKE AND DIP OF FRACTURES

- Inclined
- Vertical

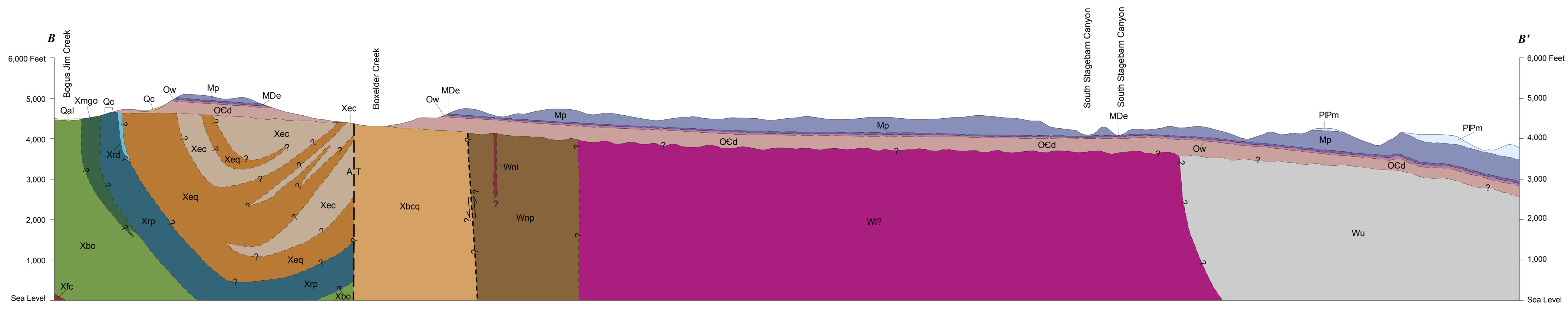
KARST FEATURES

- Stream loss zone

OTHER FEATURES

- Magnetic high — Located by ground magnetic survey. Queried where uncertain
- Open pit mine
- Mine adit or cave
- Prospect pit
- Group of prospect pits
- Mine shaft
- Open pit mine or quarry — fm -fill materials; ir -iron ore

Publication Date: May 22, 2009



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