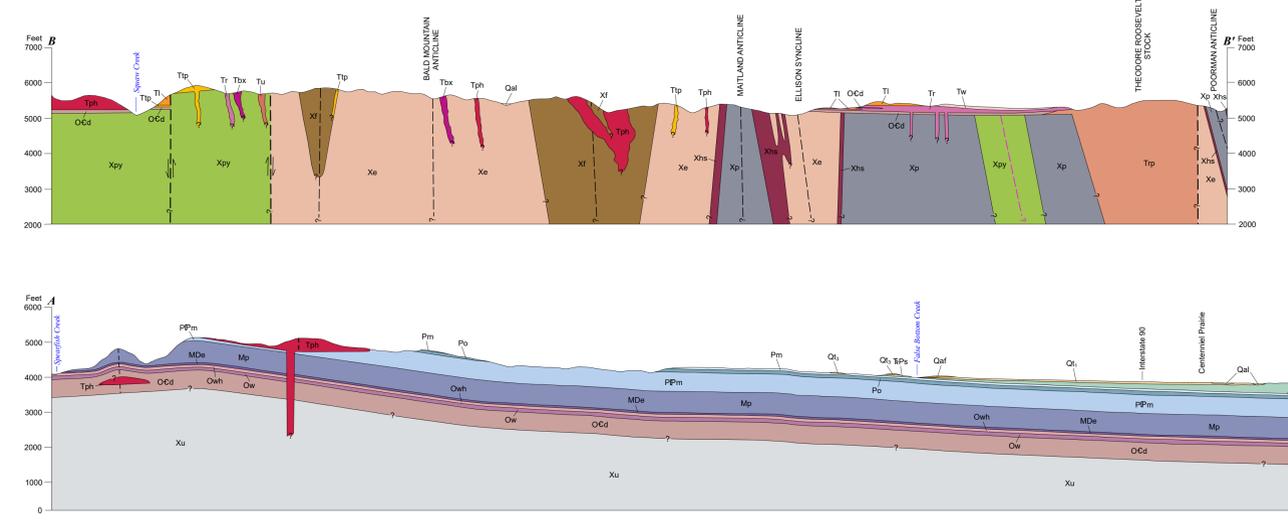
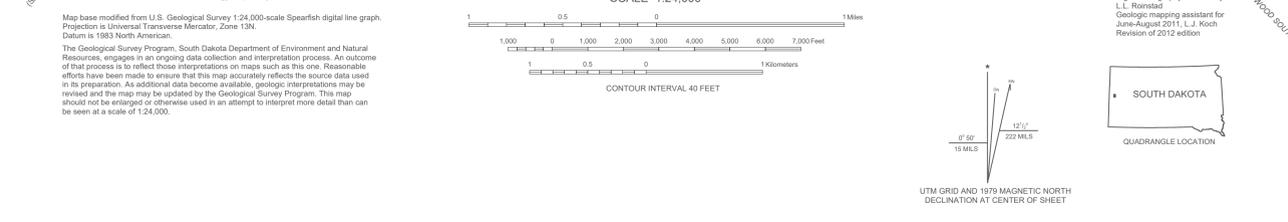


GEOLOGIC MAP OF THE SPEARFISH QUADRANGLE, SOUTH DAKOTA

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SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF FINANCIAL AND TECHNICAL ASSISTANCE
GEOLOGICAL SURVEY PROGRAM
7.5 MINUTE SERIES GEOLOGIC QUADRANGLE MAP 21



EXPLANATION

QUATERNARY	Qal Alluvium - Unconsolidated to loosely consolidated; clasts to boulder-size deposited in present-day stream drainages. Maximum thickness of 65 ft (19.8 m) reported from well logs.	Qd Terrace deposit 1 - Unconsolidated to loosely consolidated; clasts to boulder-size. Deposited approximately 3-15 ft (0.9-4.6 m) above present-day stream drainages. Maximum thickness of 7 ft (2.1 m) reported from well logs.	Qd2 Terrace deposit 2 - Unconsolidated to loosely consolidated; clasts to boulder-size. Deposited approximately 20 ft (6.1 m) above present-day stream drainages. Estimated maximum thickness 40 ft (12.2 m).	Qd3 Terrace deposit 3 - Unconsolidated to loosely consolidated; clasts to boulder-size. Deposited approximately 40-80 ft (12.2-24.4 m) above present-day stream drainages. Estimated maximum thickness approximately 50 ft (15.2 m).	Qd4 Terrace deposit 4 - Unconsolidated to loosely consolidated; clasts to boulder-size. Deposited approximately 80-120 ft (24.4-36.6 m) above present-day stream drainages. Estimated maximum thickness approximately 90 ft (27.4 m).	Qa Talus deposit - Angular blocks of locally derived bedrock deposited on steep slopes. Typically devoid of soil or vegetation.	Ql Landslide - Unconsolidated, angular blocks of locally derived bedrock and debris deposited along steep slopes as slumps and rockfalls.	Qaf Alluvial fan - Locally derived sand and gravel deposited at mouths of drainages. Estimated maximum thickness 50 ft (15.2 m).
Oligocene - Eocene	Uncertainty White River Group - Bentonitic clay, sand, and gravel. Unconsolidated to moderately consolidated. Clasts to boulder-size; dominance of Psecambrian rock types with Paleozoic, Ordovician and Tertiary geosynclinal facies. Fine grained matrix and bentonitic clay content variable. Estimated thickness up to 230 ft (70.1 m), with thickness possibly associated with erosional channels. Uncertainty Phonolite - Greenish-gray, dark bluish-gray, to dark-gray, weathering to brown and gray. Aphanitic to porphyritic, having an aphanitic to phenocrystic groundmass of orthoclase with perthite, becoming finer-grained along margins. Contains as much as 45% phenocrysts of orthoclase, sanidine, and plagioclase up to 0.75 in (2 cm) across that are typically zoned and commonly lath-shaped. Also contains up to 45% hornblende crystals as large as 0.4 in (10 mm), often enclosing feldspar and as dots and radial inclusions. May have as much as 20% subvolcanic grains of nepheline in a sodalite up to 0.1 mm, with some altered to zoelite. Sil at Rubicon Gulch contains phenocrysts of hornblende with perthite-epidote rims. Accessory minerals include hornblende, zircon, apatite, hematite, leucosane, titanite, rutile, and magnetite. Some intrusions weather along planes of trachyte texture with a gray, lath-shaped appearance along intrusion margins (Larsen, 1977; Sofronoff, 1979). A dike in the Homestake mine on the Lead quadrangle has a K:Ar date of 52.2 ± 1.7 Ma (Hildner, 1971). Breccia - Heterolithic breccia, reddish- and yellowish-brown to beige and irregularly shaped bodies, clast supported. Composed of approximately 40-60% angular to rounded clasts of Tertiary igneous rocks and Precambrian schist and quartzite as much as 6 in (15.2 cm) in diameter in a very fine crystalline to aphanitic, mylonitic, quartz-feldspar matrix. Typically oxidized, iron-stained, or hydrothermally altered (Larsen, 1977). Rhyolite - Light-gray, yellowish-brown, pinkish, to cherty-white. Finely crystalline to aphanitic groundmass of 40-60% potassium feldspar and 25-35% quartz. Contains as much as 1% plagioclase, orthoclase, and sanidine phenocrysts up to 0.1 in (2.5 mm) diameter. Some feldspars are replaced by quartz. Accessory minerals include minor magnetite, hematite, and garnet. Silica, hematite, and limonite occur as alterations. May have breccia along contacts, flow breccia from aligned biotite crystals, or shearing from closely spaced fractures parallel to the flow layering (Sofronoff, 1979). Rhyolite porphyry - Leucocratic, white, light-gray, to pinkish, having reddish- to yellowish-brown iron oxide staining where weathered. Finely crystalline to aphanitic groundmass of approximately 40-50% potassium feldspar, 8-15% oligoclase, and 30% quartz. Contains as much as 57% euhedral phenocrysts of zoned and lath-shaped orthoclase, sanidine, and plagioclase up to 1.4 in (3.5 cm) across, and up to 25% anhedral to euhedral, zoned, bi-modal quartz phenocrysts up to 0.2 in (5 mm) diameter which are well developed in the Mount Theodore Roosevelt block. Most feldspars are zoned, and partially altered to sericite or kaolin. May contain biotite and up to 1% of white mica. Magnetite, hematite, and garnet are altered to hematite. Accessory minerals include minor magnetite, garnet, and zircon. Limonite, calcite, and clay occur as alterations. Has conchoidal fracture, and a blocky appearance in outcrop due to closely spaced joints. May have flow breccia, especially at intrusion margins (Heldt, 1977; Larsen, 1977; Sofronoff, 1979). Quartz porphyry - Leucocratic, light-gray to tan. Aphanitic groundmass of alkali feldspar contains up to 50% medium to very coarse crystalline phenocrysts of alkali feldspar, and gray, lath-shaped quartz that are partially resorbed. Matrix minerals are absent. Most feldspars phenocrysts are replaced with clay and iron oxide. Exposures are highly weathered. Similar in appearance to rhyolite porphyry (Larsen, 1977). Feldspar porphyry - Gray where fresh, purplish-pink and green where weathered. Composed of 30-60% clear to grayish, subhedral to anhedral orthoclase phenocrysts 0.02-0.1 in (0.5-2.5 mm) diameter in a dark-colored aphanitic, potassium feldspar groundmass. Contains 3-5% lath-shaped apatite and apatite crystals, rounded quartz phenocrysts 0.04-0.08 in (1-2 mm) in diameter. Very fine-grained disseminated pyrite occurs near contacts with quartz monzonite porphyry. Small hematite-filled, lath-shaped voids are from altered sericite. Groundmass typically altered to iron oxide and kaolin (Larsen, 1977). Trachyte porphyry - Gray to brownish-gray with orange iron oxide staining. May be porphyritic with a fine-grained equigranular potassic feldspar groundmass. Contains up to 2% acicular perthite-augite as much as 0.2 in (5 mm) across having potassic feldspar intergrowths, and up to 35% anhedral to euhedral phenocrysts of plagioclase and sanidine to 0.5 in (12 mm) across. The plagioclase is zoned and lath-shaped. Feldspars may be lath-shaped and have fracture fillings of hematite or carbonate. Contains up to 1% hematite commonly in leucosane, and sparse euhedral titanite crystals to 0.1 in (2 mm) (Sofronoff, 1979). Monzonite porphyry - Leucocratic, gray where fresh, tan, red, yellow to white where weathered. Phanitic, granular groundmass of plagioclase and alkali feldspar includes quartz that is commonly anhedral and overwelded feldspar. Contains 50-70% zoned, subhedral to subequidimensional and alkali feldspar phenocrysts up to 0.3 in (10 mm) diameter, and 3-5% quartz phenocrysts as much as 0.16 in (4 mm) diameter. Sulfide-bearing where fresh, highly oxidized where exposed. May replace many plagioclase phenocryst cores. Aggregates of pyrite and calcite replace original mafic minerals. Gradational into quartz monzonite porphyry, but phenocrysts are more abundant and larger than 0.2 in (5 mm) diameter (Larsen, 1977). Quartz monzonite porphyry - Gray where fresh, red, yellow, to white where weathered. Locally non-banded. Phanitic, equigranular quartz-plagioclase-alkali feldspar groundmass contains approximately 10% potassium feldspar and 40% plagioclase as subhedral to subequidimensional phenocrysts as much as 0.2 in (5 mm) diameter, and 10-15% euhedral quartz. Some feldspars are altered to clay, sericite, and kaolin. Contains abundant partially resorbed quartz, pyrite, chlorite, calcite, and clay. Replace ferromagnesian minerals. May have up to 5% pyrite and 0.1% magnetite, especially along argillized and silicified contacts with schist and amphibolite. Gradational into monzonite porphyry, but phenocrysts are less abundant and smaller than 0.2 in (5 mm) diameter (Larsen, 1977). Lathite - Pale-gray to brownish with orange iron oxide staining where weathered. Groundmass of equigranular potassic feldspar contains less than 10% quartz, and approximately 35% phenocrysts of 0.1-1 in (2.5-25 mm) zoned plagioclase having albite twinning, sanidine, and biotite rimmed with perthite. Feldspars may be altered to kaolin, and pyroxene to iron oxide. Has minor apatite. Iron oxide occurs along fractures and as small irregular patches (Sofronoff, 1979). Tp Lathite porphyry - Gray to greenish-gray, having an aphanitic groundmass of potassium feldspar and perthite. Contains 45-60% white, zoned plagioclase phenocrysts, some with orthoclase cores and rims, and 5% anorthoclase phenocrysts that may be altered to sericite and feldspar. Feldspars may be altered to kaolin, and pyroxene to iron oxide. Has minor apatite. Iron oxide occurs along fractures and as small irregular patches (Sofronoff, 1979). Tu Undifferentiated Tertiary igneous rocks - Leucocratic to mesocratic, aphanitic to porphyritic, hyaloclastic intrusive rocks. Includes phonitic, rhyolitic, trachytic, monzonitic, and lathitic rocks.							
CRETACEOUS	Nonconformity Lakota Formation - Quartz arenite, yellowish-orange to tan, white, to light-maroon, fine-grained, and brown to light-gray mudstone and siltstone. Thin- to medium-bedded. Exposed thickness approximately 180 ft (54.9 m). Morrison Formation - Bentonitic claystone, siltstone, and sandstone with minor limestone, variegated gray, green, maroon, and yellow. Weathers with a popcorn-like appearance. Typically forms a grass-covered slope below the Lakota Formation. Approximate thickness 450 ft (137.16 m). Disconformity Sundance Formation - Includes the Stockade Beaver Shale, Hullet Sandstone, LAK, and Redwater Shale members. Thickness approximately 160-200 ft (48.8-61.0 m). Jr Redwater Shale Member - Shale, siltstone, and minor sandstone, tan to greenish-gray, fine-grained, laminated to thin-bedded. Contains fossils of <i>Pachydictya</i> sp. Thickness 40-50 ft (12.2-15.2 m). Disconformity LAK Member - Siltstone and fine sandstone, brownish-orange to reddish-brown, poorly bedded to massive. Thickness approximately 50 ft (15.2-15.3 m). Jsh Hullet Sandstone Member - Quartz arenite, tan to yellowish-orange, fine-grained, thin-bedded, with shaly interbeds. Contains abundant ripple marks and trace fossils. Thickness 40-50 ft (12.2-15.2 m). Jss Stockade Beaver Shale Member - Shale, siltstone, and sandstone, greenish-gray. Laminated to thin-bedded, calcareous. Contains fossils of <i>Pachydictya</i> sp. Thickness 30-40 ft (9.1-12.2 m). Jgs Gypsum Spring Formation - Gypsum, white to light-gray, thick-bedded with thin interbedded reddish siltstone and shale. Thickness 35-40 ft (10.7-12.2 m).							
TRIASSIC	Spearfish Formation - Sp - Mudstone and siltstone, red to brownish-red with white gypsum veinlets throughout. Spag - Gypsum beds up to 20 ft (6.1 m) thick occurring near the middle and the top of the formation. Thickness approximately 350 ft (106.7 m). Disconformity Pm Minnekahta Limestone - Micritic, pink, purple-gray, to beige. Very finely crystalline, laminated to thin-bedded. Petroferruginous and when broken. Contains abundant stromatolites. Typically forms a resistant cliff. Thickness 35-45 ft (10.7-13.7 m).							
PERMIAN	Disconformity Po Opeche Shale - Shale and siltstone, dark-red, orange, to reddish-brown with calcareous sandstone lenses. Upper several feet is purplish from alteration due to groundwater movement. Thickness 80-115 ft (24.3-35.1 m). Disconformity PPm Minnelusa Formation - Quartz arenite, shale, and limestone, reddish, brownish, yellowish, and beige. Many beds in the upper portion of the formation are contorted and brecciated due to evaporite dissolution. Redden terra rossa and local conglomerate of angular chert fragments derived from the Palisades Limestone occur along the lower contact. Thickness 450-550 ft (137.2-167.6 m). Disconformity Mp Pahsapa Limestone - Limestone and dolomite limestone, white, beige, to gray. Thin-bedded, finely to coarsely crystalline. Contains thin lenses and beds of gray to brown chert and local solution breccia. Vuggy, with cavities occurring mainly in the upper portion of the formation. Forms prominent cliffs. Thickness 475-500 ft (144.8-152.9 m). MDs Englewood Limestone - Shale, pink, gray, to purple-gray grading upward into purple to pinkish-gray argillaceous limestone and dolomite. Laminated to medium-bedded, very finely to medium crystalline. Most beds are bioturbated. Locally contains bryonid, chalcydroid-replaced evaporite nodules. Thickness 40-50 ft (12.2-15.8 m).							
PENNSYLVANIAN	Disconformity OCd Deadwood Formation - Basal conglomerate and thick-bedded quartz arenite, brown, gray, to tan overlain by glauconitic shale, siltstone, sandstone, and minor interturbidite conglomerate. Middle and upper beds of laminated to thick-bedded, brown, gray, to dark-green, botryoidal glauconitic shale and low-angle, interturbidite, calcareous sandstone. Combined thickness 60-80 ft (18.3-24.4 m).							
MISSISSIPPIAN	Disconformity Xp Poorman Formation - Xp - Granophytic phyllite, sericite- and biotite-rich carbonates, and quartz-bearing phyllite, light-gray to black. Fine-grained, laminated to thin-bedded with prominent banding, especially in the upper 100 ft (30.5 m). Locally with white to gray metachert layers containing variable amounts of quartzite. Original thickness of 100 ft (30.5 m) based on metamorphism. Presently 0-164 ft (0-50.0 m) thick, increasing to 410 ft (125.0 m) thick in bed logs. Prosser carbonates consist of siltstone, chert, and chert (Cadey et al., 1991) on the Lead quadrangle.							
DEVONIAN	Disconformity OCa Deadwood Formation - Basal conglomerate and thick-bedded quartz arenite, brown, gray, to tan overlain by glauconitic shale, siltstone, sandstone, and minor interturbidite conglomerate. Middle and upper beds of laminated to thick-bedded, brown, gray, to dark-green, botryoidal glauconitic shale and low-angle, interturbidite, calcareous sandstone. Combined thickness 60-80 ft (18.3-24.4 m).							

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Talus slope of Tertiary phonolite (Tph) on the south side of Mt. Theodore Roosevelt, elevation 6219 ft (1920 m). Tertiary Peak, elevation 7064 ft (2153 m). The largest boulders are over 8 ft (2.4 m) across.

Tertiary rhyolite (Tr) with vertical jointing overlying weathered sandstone beds of the Deadwood Formation (OCd) along Matfield Road.

Lookout Peak. The Spearfish Formation (SPs) makes up the "Red Valley" in the foreground, and is overlain by the white Gypsum Spring Formation (Jgs). The Sundance Formation is represented by a small exposure of the Hullet Sandstone Member (Jsh). The Morrison Formation (Jm) is covered. The Lakota Formation (LAK) forms a resistant cap. The Thoen Stone, an inscribed rock left by gold prospectors being the Black Hills in 1834, was found at the base of the peak in 1887 by Louis Thoen.