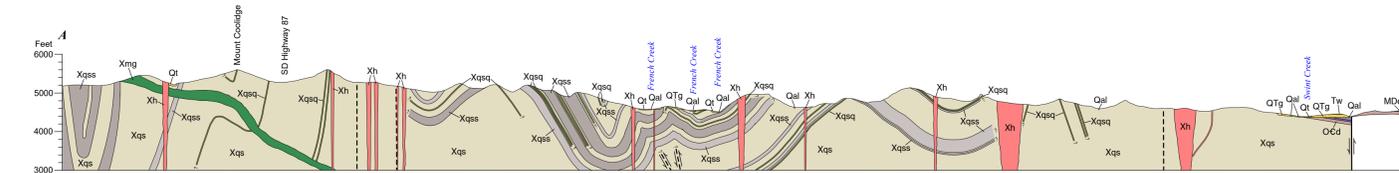
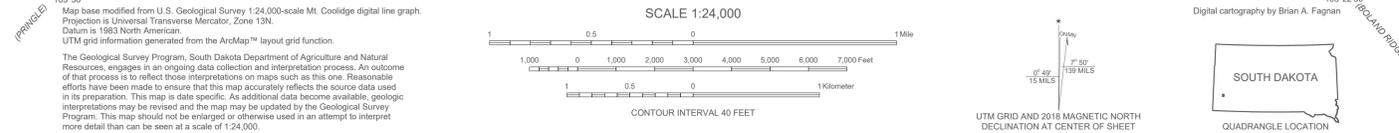
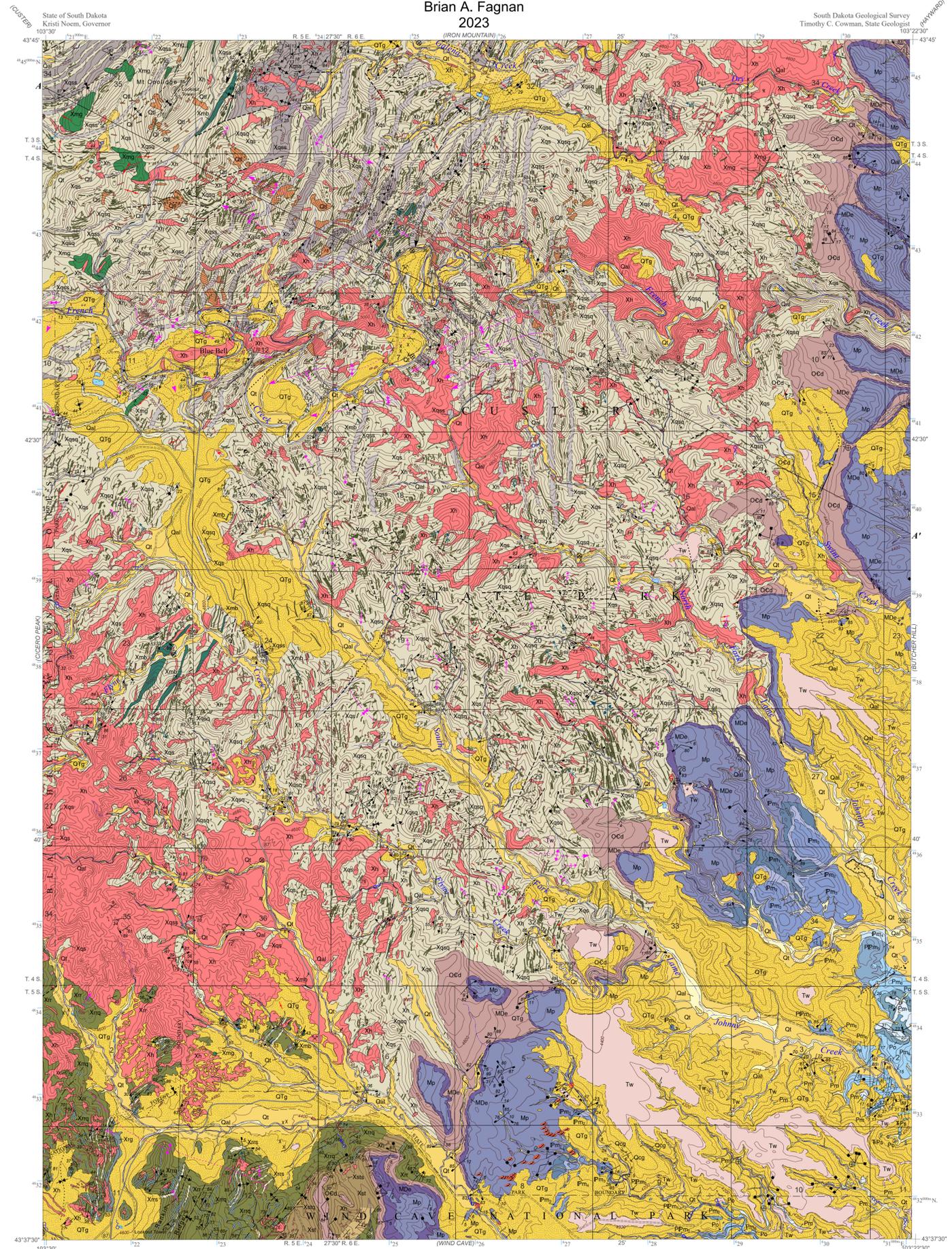


GEOLOGIC MAP OF THE MT. COOLIDGE QUADRANGLE, SOUTH DAKOTA

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Metagabbro (Xmg). Stylus approximately 6 in (152 mm).
A ridge of quartzite (Xqs) in Xqs indicating bedding and orientation. Bedding dips toward the left of the picture.
Quartzite-mica-sillimanite schist (Xqs) in Xqs.
Interbedded quartz-muscovite schist (Xqms) with quartzite (Xqs) in Xqs.
Sulfide mineralization and brecciation along fractures of quartzite beds (Xqsq) in Xqs.
A sill of Harney Peak Granite (Xh), containing a pegmatite deposit near the top, overlying a quartzite bed (Xqs) in Xqs.
Metabasalt (Xmb), right side of picture, parallel to bedding in Xqs along a quartzite bed (Xqs) in Xqs.

EXPLANATION

QUATERNARY	Qal Alluvium - Unconsolidated to loosely consolidated, clay- to boulder-sized clasts deposited in drainages and as overbank material during floods. May include undifferentiated terrace deposits occurring 1-5 ft (0.3-1.5 m) above stream level.	Qcl Landslide - Coherent talus slumps and debris flows of randomly oriented, unconsolidated, poorly sorted, locally derived bedrock and soil occurring along steep slopes.	Qtd Talus deposit - Angular blocks of locally derived bedrock debris to boulder-size without soil or vegetation. Typically deposited below resistant rock units.	Qti Terrace deposit - Undifferentiated terrace deposits occurring 5-40 ft (1.5-12.1 m) above stream level. Unconsolidated to poorly consolidated, clay- to boulder-sized clasts. Represents up to two depositional occurrences of terrace deposits. Maximum thickness approximately 20 ft (6.1 m).	Qcg Conglomerate - Well-cemented, angular to subangular, sand- to pebble-sized clasts, derived from Precambrian and early Paleozoic lithologies. Matrix is composed of calcium carbonate and calcium sulfate probably derived from hot springs (Wolcott, 1967). Some conglomerate could be associated with the White River Group but were not differentiated in the study area. Approximate thickness 2-15 ft (0.6-4.6 m).	QTg Gravel deposit - Unconsolidated to loosely consolidated, clay- to boulder-sized clasts comprised of Precambrian lithologies and minor Paleozoic lithologies deposited as part of or redeposited from the White River Group. Gravel is sub-rounded to rounded and spreads down slope up to 200 feet below the base of the White River Group. May include up to four undifferentiated Quaternary terrace deposits occurring 5-200 ft (1.5-61.0 m) above stream level.	Tertiary	Tw White River Group - Variable amounts of unconsolidated to moderately consolidated pebble- to boulder-sized gravel with tan, brown, and light-gray bentonitic siltstone and claystone. Gravel is sub-rounded to rounded and is comprised of Precambrian lithologies with very minor amounts of Paleozoic lithologies. Partly equivalent to gravel deposit QTg. Estimated maximum thickness 80 ft (24.3 m).
TRIASSIC	Unconformity		TPs Spearfish Formation - Red to rose colored shale and siltstone. Interbedded, irregular limestone beds up to 2 ft (0.6 m) thick locally near the base. Discontinuous gypsum beds observed outside the field area.	Pm Minnekahta Limestone - White, pink, purple, finely crystalline, laminated to thin-bedded limestone. Interbedded with thin layers of shale at the middle and base. Forms prominent dip slopes and cliffs. Contains minor folds and box folds throughout the formation. Locally petroliciferous odor when broken. Approximate thickness 40-50 ft (12.2-15.2 m).	Permian	Disconformity	Pp Opeche Shale - Red to maroon mudstone, shale, and siltstone. Lavender zone at top approximately 5 ft (1.5 m) thick due to ground-water leaching. Poorly exposed on slopes below Minnekahta Limestone. Estimated thickness 40-100 ft (12.2-30.5 m).	
PERMIAN	Disconformity		Pm6 Minnelusa Formation (unit 6) - Tan, gray, yellow, to red brecciated limestone interbedded with thin beds of mostly brecciated limestone, discontinuous thin layers of anthracite, and thin beds of cross-bedded sandstone, all poorly exposed. Top of unit contains bright-red interbedded shale and sandstone. Sandstone beds form prominent resistant benches. Approximate thickness 110-130 ft (33.5-39.6 m).	Permian	Disconformity	Pm5 Minnelusa Formation (unit 5) - Bright-red, yellow, light-tan, to gray, fine- to coarse-grained sandstone with light-blue-gray chert nodules near base. Upper portion is a red to light-red breccia with a carbonate matrix. A dark-red sandstone separates the lower and upper portions. Approximate thickness 80-100 ft (24.3-30.5 m).		
PENNSYLVANIAN	Disconformity		Pm4 Minnelusa Formation (unit 4) - Dolomite interbedded with sandstone and laminated limestone. Brownish- to grayish-yellow. At the base is a light-red to grayish-yellow, calcareous, medium- to coarse-grained sandstone, 1.0 ft (0.3-1.5 m) thick. Dolomite beds commonly contain manganese oxide dendrites. Unit weathers to colloidal slopes. Approximate thickness 80-112 ft (24.3-34.1 m).	Upper Pennsylvanian	Disconformity	Pm3 Minnelusa Formation (unit 3) - Locally silicified sandstone interbedded with shale. Brownish- to grayish-yellow. Poorly exposed, except for silicified outcrops, and weathers to colloidal slopes. Estimated thickness is 80-120 ft (24.3-36.6 m).		
MISSISSIPPIAN	Disconformity		Pm2 Minnelusa Formation (unit 2) - Limestone, thin bedded. Yellowish-gray to light-gray. Contains distinctive red and white chert nodules, especially near the top. Limestone beds are up to 2 ft (0.6 m) thick and interbedded with sandstone and shale layers as much as 0.5 ft (0.15 m) thick. Poorly exposed. Estimated thickness is 35-50 ft (10.6-15.2 m).	Lower Mississippian	Disconformity	Pm1 Minnelusa Formation (unit 1) - Sandstone, grayish-yellow to moderate-red, medium- to coarse-grained, cross-bedded. Overlain by a grayish-yellow to moderate-red, fine-grained siltstone which is compensatory in thickness with the sandstone. Unit is poorly exposed and weathers to colloidal slopes. Estimated thickness is 25-80 ft (7.6-24.4 m).		
DEVONIAN	Disconformity		Mp Pahassa Limestone - Gray to light-tan, cavernous limestone and dolomite limestone. Massive limestone with sparse chert nodules in the upper portion, thin- to medium-bedded, dolomite, sandy limestone in the lower portion. Forms prominent cliffs. Disconformity between the Pahassa Limestone and the overlying Minnelusa Formation (unit 1) is a paleokarst surface containing terra rosa-filled sinkholes and breccia pipes. Contains abundant tabulate corals, spirifer brachiopods, burrows, sparse gastropods and rugose corals. Approximate thickness 275-375 ft (83.8-114.3 m).	Upper Devonian	Disconformity	MDe Englewood Limestone - Argillaceous limestone, dolomite, and shale. Grayish-pink, light-gray to grayish-purple. Laminated to thin-bedded, thin- to medium crystalline. Bioturbated, locally containing crinoid columns, brachiopods, and bryozoa. Estimated thickness 35-45 ft (10.7-13.7 m).		
ORDOVICIAN	Disconformity		Ocd Deadwood Formation - Reddish-brown, basal conglomeratic sandstone, sandstone, siltstone, and shale; upper coarse-grained sandstone having nodular weathering. Laminated to thick-bedded. Contains trilobite and inarticulate brachiopod fragments. Approximate thickness 65-75 ft (19.8-22.9 m).	Lower Ordovician	Nonconformity			
CAMBRIAN	Disconformity		Xh Harney Peak Granite - Granite, beige, orange-pink, to grayish-orange. S-type, peraluminous, finely crystalline to pegmatitic. Occurs as compositionally homogeneous, layered, to zoned bodies. Dominant minerals include plagioclase, microcline perthite, quartz, and muscovite, with minor schorl, biotite and kyanite. Isolated sills and dikes are typically similar in composition to the larger bodies of granite. Age 1,715 +/- 3 Ma based on ⁴⁰ Ar/ ³⁹ Ar date for monazite (Redden and others, 1990).	Upper Cambrian	Nonconformity			
	Disconformity		Xmg Metagabbro - Intruded medium-grained hornblende plagioclase amphibole, sandstone, siltstone, and shale; upper coarse-grained sandstone having nodular weathering. Laminated to thick-bedded. Contains trilobite and inarticulate brachiopod fragments. Approximate thickness 65-75 ft (19.8-22.9 m).		Nonconformity			
	Disconformity		Xmb Metabasalt - Amphibolite. Olive-black to black sills or flows of very fine crystalline amphibole laths. Foliated. Typically having a speckled appearance; may have faint layering. Thickness 2-40 ft (0.6-12.2 m). Protolith is basalt.		Nonconformity			
	Disconformity		Xqs Quartzite and Schist - Xqs - Thick-bedded quartzite with interbeds of quartz-mica schist and quartz-mica-sillimanite schist, lacking interbedded phyllite or graywacke. Relative age uncertain. Correlation with other Early Proterozoic units in the Black Hills is poorly known. Equivalent to Metagabbro - Xq (Redden and DeWitt, 2008). Possibly equivalent to Black Mountain Quartzite (Bayley, 1972). Protolith is sandstone and shale. Thickness may be in thousands of feet. Xqg - Quartzite bed outcrop. Typically follows strike of bedding. Gray, brownish-gray, to bluish-gray. Fine- to coarse-grained, moderately sorted. Some beds have a nodular appearance, graded bedding, or contain biotite. May have fine-grained partings of micaceous quartzite, siliceous feldspathic schist, quartz-biotite schist, or coarse-grained quartz-biotite-sillimanite schist. Xqs - Muscovite-quartz schist and quartz-muscovite schist with varying amounts of biotite. Light-brown, brownish- and silvery-gray, to brownish-black. Fine- to medium-grained. Some beds are quartz-mica-sillimanite schist, with sillimanite knots 0.4 in (1 cm) across. Lighter color on map is inferred. Xqs is subdivided into the following units in the southwestern portion of the quadrangle, but could not be traced further north.		Nonconformity			
	Disconformity		Xrg Reeves Gulch Schist Unit - Quartz-biotite schist, quartz-biotite-plagioclase schist, and quartz-biotite-muscovite schist. Interbedded with thin quartzite and biotite quartzite beds typically 0.4-19.7 in (1-50 cm) thick. Contains intervals of biotite-muscovite-rich schist as much as 9.8 ft (3 m) thick. Thin-bedded to laminated, poorly exposed. Appears to grade into the Rankin Ridge Quartzite Unit (Fahrenbach, 2019).		Nonconformity			
	Disconformity		Xrr Rankin Ridge Quartzite Unit - Xrr - Quartzite and siliceous schist. Thick-bedded, clean quartzite and minor biotite quartzite interbedded with poorly exposed, fine-grained quartzite with muscovite partings, fine-grained quartz-muscovite schist, fine-grained quartz-biotite schist, and thin coarse-grained quartz-biotite-sillimanite schist. Includes thick-bedded quartzite without interbedded schist, forming cliffs and ridges of quartzite (Fahrenbach, 2019 and Fagnan and others, 2013). Xrrq - Quartzite bed outcrop. Typically follows strike of bedding. Gray, brownish-gray, to bluish-gray. Fine- to coarse-grained, moderately sorted. Some beds have a nodular appearance, graded bedding, or contain biotite. May have fine-grained partings of micaceous quartzite, siliceous feldspathic schist, quartz-biotite schist, or coarse-grained quartz-biotite-sillimanite schist. Xrs - Muscovite-quartz schist and quartz-muscovite schist with varying amounts of biotite. Light-brown, brownish- and silvery-gray, to brownish-black. Fine- to medium-grained. Some beds are quartz-mica-sillimanite schist, with sillimanite knots 0.4 in (1 cm) across. Lighter color on map is inferred.		Nonconformity			
	Disconformity		Xst Sanctuary Trail Schist Unit - Xst - Schist, plagioclase-quartz gneiss and granofels, and quartzite. Characteristic thin-bedded, muscovite-biotite-plagioclase-quartz gneiss and granofels, with and without microcline, are abundant in the upper part of the unit (Fagnan and others, 2013). Xsta - Quartzite bed outcrop. Typically follows strike of bedding. Biotite- and feldspar-bearing quartzite and pure quartzite occur throughout, but are more abundant near the top. Xstb - Coarse-grained muscovite-sillimanite-microcline-biotite-quartz schist. Schist contains less than 50 percent quartz as abundant in lower section but occurs throughout the unit. Lighter color on map is inferred.		Nonconformity			
	Disconformity		Xu Undifferentiated Precambrian rocks - Shown only in cross section		Nonconformity			

CONTACTS

Long dashed where approximately located; short dashed where inferred; dotted where concealed.

FAULTS

Long dashed where approximately located; short dashed where inferred; dotted where concealed. Bar and ball on downthrown side.

FOLDS

Syncline: Location of trace of axial plane and direction of plunge. Long dashed where approximately located; dotted where concealed.

Antiform: Location of trace of axial plane and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed.

Synform: Location of trace of axial plane and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed.

D₁ FOLDS (Early Proterozoic)

Small antiform: Showing bearing and plunge.

Small synform: Showing bearing and plunge.

Minor folding: Showing bearing and plunge.

D₂ FOLDS (Early Proterozoic)

Antiform: Location of trace of axial plane and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed.

Synform: Location of trace of axial plane and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed.

Small antiform: Showing bearing and plunge.

Small synform: Showing bearing and plunge.

Minor folding: Showing bearing and plunge.

D₃ FOLDS (Early Proterozoic)

Antiform: Location of trace of axial plane and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed.

Synform: Location of trace of axial plane and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed.

Small antiform: Showing bearing and plunge.

Small synform: Showing bearing and plunge.

Minor folding: Showing bearing and plunge.

BEDDING

Inclined: 38°

Horizontal: 39°

Vertical: 40°

Overturned: 41°

METAMORPHIC FOLIATIONS

Inclined: 42°

Vertical: 43°

IGNEOUS FOLIATIONS

Inclined: 44°

Vertical: 45°

FRACTURES

Inclined: 46°

Vertical: 47°

Multiple: 48°

Point of observation at joint of strike lines

LINEAR STRUCTURES

Mineral lineation: 49°

Showing bearing and plunge

KARST FEATURES

Stream loss zone: 50°

Breccia pipe: 51°

CONCRETIONS

Silicified carbonate concretions: 52°

Pale reddish- to light-brown with banding. Size up to 2.5 ft (0.8 m) in diameter. Some contain fossil fragments, or have a mottled texture from dissolution of fossil fragments. Typically associated with the Pahassa Limestone and Minnekahta Formation contact. Some may have been transported or are late-weathering deposits.

OTHER FEATURES

Open pit boundary: 53°

Gravel pit: 54°

Abandoned gravel or placer pit: 55°

Abandoned open pit: 56°

Shaft: 57°

Trench: 58°

Group of prospect pits: 59°

Prospect pit: 60°

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