Department of Environment and Natural Resources
Division of Financial and Technical Assistance
Geological Survey Program
7.5 Minute Series Geologic Quadrangle Map 16

Geologic Map of Wind Cave National Park

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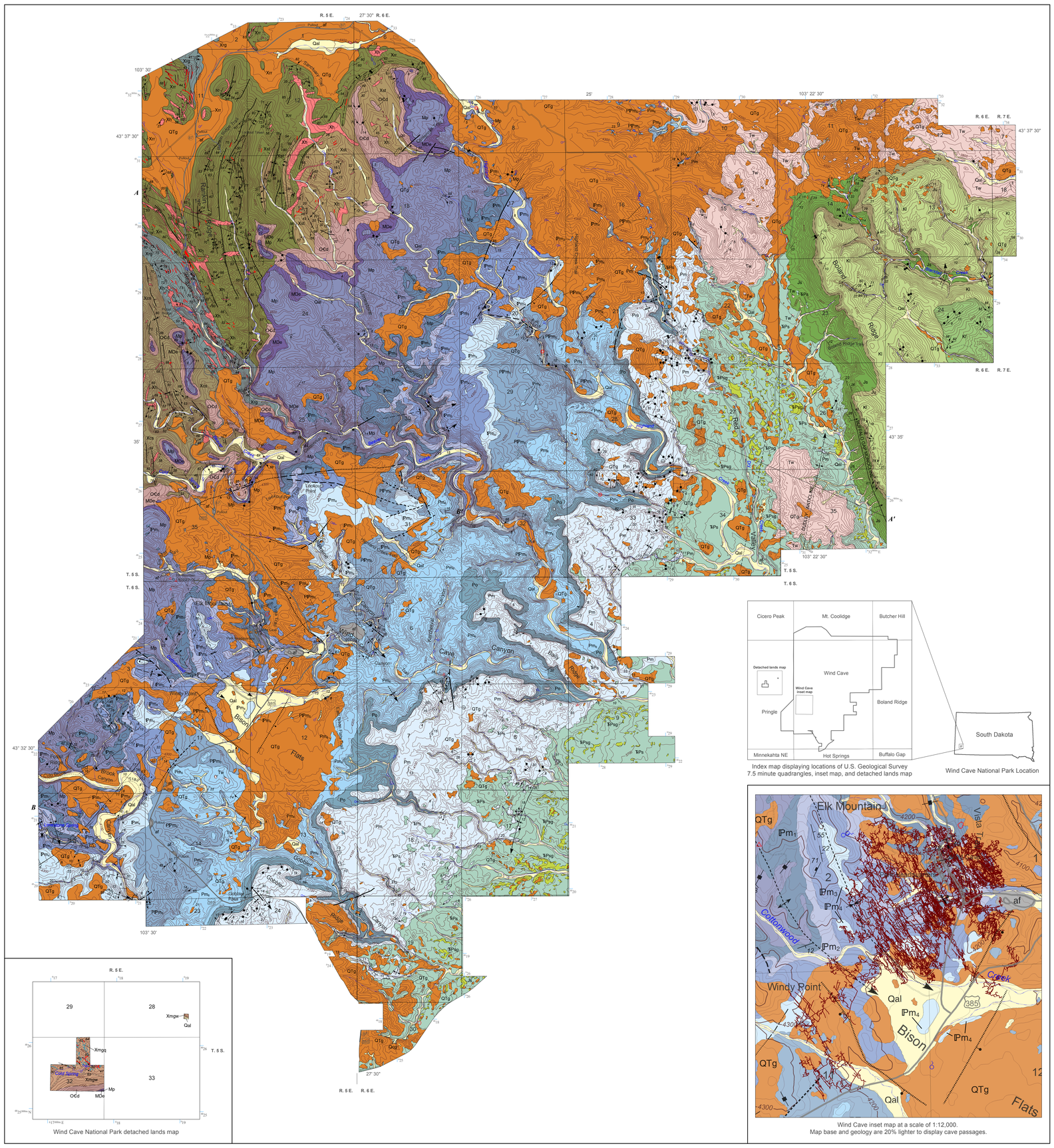
2013

Prepared in cooperation with the Department of the Interior, National Park Service, Wind Cave National Park

Prepared in cooperation with Albion College, Albion, Michigan

State of South Dakota
Dennis Daugaard, Governor

South Dakota Geological Survey
Derrie L. Iles, State Geologist



Index map displaying locations of U.S. Geological Survey 7.5 minute quadrangles, inset map, and detached lands map

Wind Cave National Park Location

Wind Cave inset map at a scale of 1:12,000.
Map base and geology are 20% lighter to display cave passages.

Wind Cave National Park detached lands map

[1]Albion College, Albion, Michigan

Field assisted by Darren W. Dyk and Jacob A. Tielke

Digital cartography by Wesley P. Christensen and Brian A. Fagnan

Map base modified from U.S. Geological Survey 1:24,000-scale Boland Ridge, Buffalo Gap Butcher Hill, Hot Springs, Mt. Coolidge, Pringle, and Wind Cave digital line graphs.
Projection is Universal Transverse Mercator, Zone 13 N.
Datum is 1983 North American.
UTM grid information generated from the Arcmap layout grid function.

The Geological Survey Program, Department of Environment and Natural Resources, engages in an ongoing data collection and interpretation process. An outcome of that process is to reflect those interpretations on maps such as this one. Reasonable efforts have been made to ensure that this map accurately reflects the source data used in its preparation. This map is date specific. As additional data become available, geologic interpretations may be revised and the map may be updated by the Geological Survey. This map should not be enlarged or otherwise used in an attempt to interpret more detail than can be seen at a scale of 1:24,000.

NORTH

APRIL 13, 2011; MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24,000

1 0.5 0 1 Mile

1,000 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 Feet

1 0.5 0 1 Kilometer

Contour Interval 20 Feet
(40 feet for Mt. Coolidge quadrangle)

Selected References

Bayley, R.W., 1972, *Preliminary geologic map of the Nemo district, Black Hills, South Dakota*: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-712, scale 1:24,000.

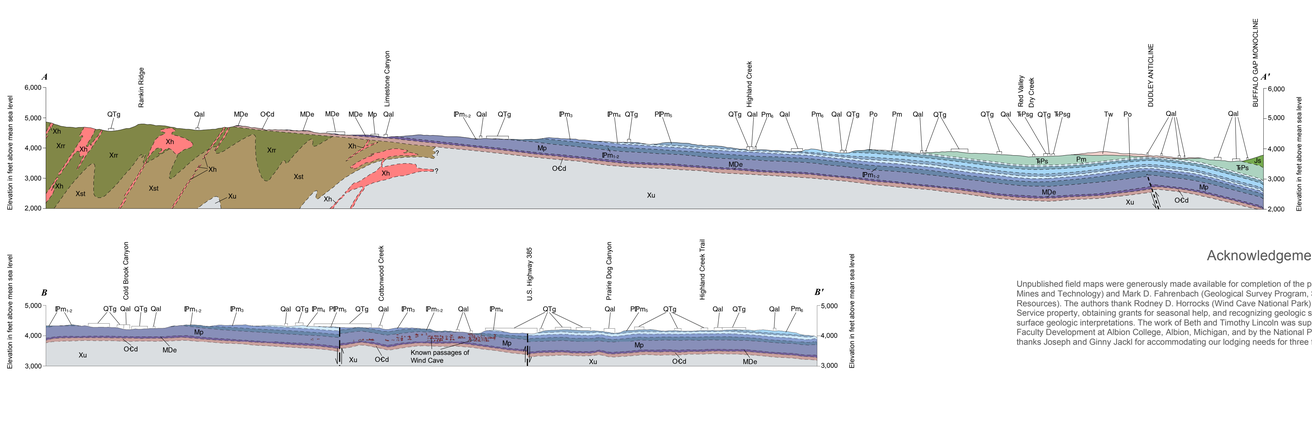
Fagnan, B.A., 2002, *Correlation of surface geology with subsurface geology and karst development at Jewel Cave National Monument, Custer County, South Dakota*: Rapid City, S. Dak., South Dakota School of Mines and Technology, M.S. thesis, 143 p.

_____2009, *Geologic map of the Jewel Cave quadrangle, South Dakota*: South Dakota Geological Survey 7.5 minute series Geologic Quadrangle Map 9, scale 1:24,000.

Redden, J.A., and DeWitt, E., 2008, *Maps showing geology, structure, and geophysics of the central Black Hills, South Dakota*: U.S. Geological Survey Scientific Investigations Map 2777, scale 1:100,000.

Redden, J.A., Peterman, Z.E., Zartman, R.E., and DeWitt, E., 1990, *U-Th-Pb geochronology and preliminary interpretaion of Precambrian tectonic events in the Black Hills, South Dakota*: in Lewry, J.F., and Stauffer, M.R., eds., *The Early Proterozoic Trans-Hudson Orogen of North America*: Geological Association of Canada Special Paper 37, p. 229-251.

Wolcott, D.E., 1967, *Geology of the Hot Springs quadrangle, Fall River and Custer Counties, South Dakota*: U.S. Geological Survey Bulletin 1063-K, p. 427-442, scale 1:24,000.



Acknowledgements

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EXPLANATION

Quaternary

Qal **Alluvium** - Unconsolidated to loosely consolidated clay, silt, and angular to rounded, sand and gravel. Deposited in present-day drainages

Qcg **Conglomerate** - Well-cemented, angular to subangular, sand- to pebble-sized clasts, derived mainly from the Minnekahata Limestone with minor quantities of 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 was 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 carbonate and sandstone. All gravels are sub-rounded to rounded. Some gravel deposits may be associated with the White River Group but were not differentiated in the study area

Disconformity

Tertiary

Oligocene to Eocene

Tw **White River Group** - Tan, brown, and light-gray siltstone, claystone, and white to light-gray, vuggy, finely-crystalline, lacustrine limestone. Contains sparse lenses of conglomerate indicating possible stream channels. Some gravel deposits of unit QTg could be associated with the White River Group but were not differentiated in the study area. Exposed thickness greater than 200 ft (61 m)

Disconformity

Cretaceous

Lower Cretaceous

Kf **Fall River Formation** - Gray to light-gray, fine- to very fine-grained, thin-bedded, carbonaceous sandstone interbedded with laminated, carbonaceous siltstone. Exposed thickness greater than 100 ft (30.5 m)

Disconformity

Kl **Lakota Formation** - Tan, brown, and light-gray, medium- to coarse-grained, crossbedded sandstone interbedded with mudstone. Middle of the formation contains lenses of sandy limestone. Forms prominent outcrops; large boulders may occur as colluvium or talus. Contains petrified wood. Approximate thickness 200-350 ft (61-106.7 m)

Disconformity

Jurassic

Upper Jurassic

Ju **Unkpapa Sandstone** - Buff to white, calcareous, well-sorted, friable, quartz sandstone. Locally pink to purple in the top of the formation. Fine- to medium-grained, crossbedded. Approximate thickness 10-50 ft (3.0-15.2 m)

Disconformity

Js **Sundance Formation** - Includes the members listed below, which are observed in the field but not shown separated on the map or cross section. Approximate thickness 240-270 ft (73.2-82.3 m)

Redwater Shale Member - Light gray-green, calcareous, glauconitic siltstone and sandstone. Contains the fossil *Pachyteuthis* sp. Distinct as a marker bed when seen in outcrop

Disconformity

Middle Jurassic

Lak Shale Member - Red, fine-grained, calcareous, glauconitic siltstone and sandstone. Distinct as a marker bed when seen in outcrop

Hulett Sandstone Member - Light-gray, fine-grained, calcareous, glauconitic sandstone interbedded with grayish-green claystone. Contains abundant ripple marks

Stockade Beaver Shale Member - Tan to light gray-green, calcareous, glauconitic, thin-bedded shale, sandstone, and siltstone. Contains the fossil *Pachyteuthis* sp.

Canyon Springs Sandstone Member - Tan, gray, and yellow, medium-grained, crossbedded sandstone. Contains ripple marks

Disconformity

Triassic

Lower Triassic

$Psg / $Ps **Spearfish Formation** - Red to maroon shale and siltstone. Interbedded brecciated limestone beds up to 2 ft (0.6 m) thick locally near the base. Discontinuous gypsum beds (TPsg) up to 3 ft (0.9 m) thick are abundant locally near the top, with small veins and lenses throughout the middle to the top of the formation. Dissolution features are indicated by fragments of shale and siltstone silicified in the gypsum. Approximate thickness 350-400 ft (106.7-121.9 m)

Disconformity

Permian

Upper Permian

Pm **Minnekahta Limestone** - White, pink, and 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 petroliferous odor when broken. Approximate thickness 40-50 ft (12.2-15.2 m)

Disconformity

Po **Opeche Shale** - Unconsolidated red to maroon shale, mudstone, and siltstone having lavender coloring in the upper 5 ft (1.5 m). Erodes easily, weathering to a fine soil. Poorly exposed on slopes beneath the Minnekahta Limestone. Approximate thickness 80-100 ft (24.4-30.5 m)

Disconformity

Lower Permian

Pm$_6$ **Minnelusa Formation (unit 6)** - Tan, gray, yellow, to red brecciated sandstone interbedded with thin beds of mostly brecciated limestone, discontinuous thin layers of anhydrite, and thin beds of unbrecciated sandstone, all poorly exposed. Limestone contains brachiopods.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)

Disconformity

Pennsylvanian

Upper Pennsylvanian

PPm$_5$ **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 (24.4-30.5 m)

Disconformity

Pm$_4$ **Minnelusa Formation (unit 4)** - Brownish-yellow to tan dolomite interbedded with sandstone and laminated limestone. Dolomitic beds may contain manganese dendrites. Weathers into colluvial slopes. Approximate thickness 60-80 ft (18.3-24.4 m)

Disconformity

Pm$_3$ **Minnelusa Formation (unit 3)** - Brownish-yellow to tan, locally silicified sandstone interbedded with shale. Poorly exposed, except for silicified sandstone interbedded with shale. Weathers into colluvial slopes. Top of unit may contain a brownish-yellow to light-gray, sandy limestone. Approximate thickness 100-120 ft (30.5-36.6 m)

Pm$_2$ **Minnelusa Formation (unit 2)** - Yellowish-gray to light-gray, thin-bedded limestone. 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 up to 0.5 ft (0.2 m) thick. Poorly exposed. Approximate thickness is 40-60 ft (12.2-18.3 m)

Pm$_1$ **Minnelusa Formation (unit 1)** - Tan or red, medium- to coarse-grained, cross-bedded, basal sandstone. Overlain by tan or red, fine-grained, upper siltstone which is compensatory in thickness with the basal sandstone. Poorly exposed and weathers into colluvial slopes. Approximate thickness is 25-90 ft (7.6-27.4 m)

Disconformity

Mississippian

Lower Mississippian

Mp **Pahasapa Limestone** - Gray to light-tan, cavernous limestone and dolomitic limestone. Massive limestone with sparse chert nodules in the upper portion; thin- to medium-bedded, dolomitic, sandy limestone in the lower portion. Forms prominent cliffs. Disconformity between the Pahasapa Limestone and the overlying Minnelusa Formation (unit 1) is a paleokarst surface containing terra rosa-filled sinkholes and breccia pipes. Contains abundant tabulate corals, spiriferid brachiopods, burrows, sparse gastropods and rugose corals. Approximate thickness 275-375 ft (83.8-114.3 m)

Devonian

Upper Devonian

MDe **Englewood Limestone** - Lavender, mauve to pink, interbedded limestone, dolomitic limestone, and purple-gray shale. Laminated to medium-bedded. Finely to medium crystalline with some coarse-grained crinoidal beds. Bioturbated; contains sparse rugose corals, spiriferid brachiopods, and crinoid columnals. Thickness 35-50 ft (10.7-15.2 m)

Disconformity

Ordovician

Lower Ordovician

Cambrian

Middle to Upper Cambrian

OCd **Deadwood Formation** - Reddish-brown, basal conglomeratic sand-stone and local conglomerate; middle glauconitic sandstone, siltstone, and shale; upper coarse-grained sandstone having nodular weathering. Lami-nated to thick-bedded. Contains trilobite and inarticulate brachiopod frag-ments. Approximate thickness 65-75 ft (19.8-22.9 m)

Unconformity

Precambrian

Lower Proterozoic

Xh **Harney Peak Granite** - Sills and dikes of predominantly coarse-grained to pegmatitic, tan to pink S-type granite. Age 1,715 Ma ± 3 Ma (Redden et al, 1990)

Unnamed formation Xq (Redden and DeWitt, 2008) Possibly equivalent to Buck Mountain Quartzite of Bayley (1972). Here subdivided into the following units:

Xmqg / Xmgw **Micaceous metagraywacke unit** - Muscovite schist to quartz-mica schist. Brown, grayish-brown to gray. Laminated to thin-bedded. Xmgq - Quartzite, reddish-brown to gray. Thin-bedded to massive, fine- to medium-grained, micaceous. A massive bed up to 30 ft (9.1 m) thick occurs at the top of the unit

Xcs **Cold Spring Creek quartzite unit** - Interbedded quartz-ite and micaceous schist. Some quartzite layers near base are biotite-bearing, upper quartzite layers are typically pure. Includes sections of thick-bedded quartzite without interbedded schist, resulting in cliff- and ridge-forming quartzite intervals up to 40 ft (12.2 m) thick. Interbedded schists include laminated microcline-biotite schist, muscovite-biotite schist, and garnet-muscovite-biotite-quartz schist

Xrg **Reaves Gulch schist unit** - Biotite schist and thick- to thin-bedded impure quartzite and biotite quartzite interbedded with thin-bedded to laminated biotite-quartz schist, plagioclase-biotite-quartz schist, and muscovite-biotite-quartz schist. Also contains minor thick quartzite beds, intervals of uniform, muscovite-biotite-rich schist, and minor garnet-rich layers which contain up to 3 percent manganese. Contains abundant amphibolite layers outside of Wind Cave National Park

Xrr **Rankin Ridge quartzite unit** - Quartzite and siliceous schist. Thick-bedded, clean quartzite and minor biotite quartzite interbedded with poorly exposed, fine-grained quartzite with muscovite partings, fine-grained muscovite-quartz schist, fine-grained biotite-quartz schist, and thin coarse-grained sillimanite-biotite-quartz schist. Includes thick-bedded quartzite without interbedded schist, forming cliffs and ridges of quartzite intervals up to 70 ft (21.3 m) thick. Some quartzite beds are graded allowing determination of tops

Xst **Sanctuary Trail schist unit** - Schist, plagioclase-quartz gneiss and granofels, and quartzite. Coarse-grained muscovite-sillimanite-microcline-biotite-quartz schist containing less than 50 percent quartz is abundant in lower section but occurs through-out the unit. Characteristic thin-bedded, muscovite-biotite-plagio-clase-quartz gneiss and granofels, with and without microcline, are abundant in the upper part of the unit. Biotite- and feldspar-bearing quartzite and pure quartzite occur throughout, but are more abundant near the top

Xu **Undifferentiated Lower Proterozoic rocks** - Shown only in cross section

Contact, Form line

Contact — Long dashed where approximately located; short dashed where inferred only in cross section; arrow indicates contact dip direction and amount

Form line — Tic indicates dip direction of beds

FAULT

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

FOLDS

Anticline — Showing crestline and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed

Syncline — Showing troughline and direction of plunge. Long dashed where approximately located; short dashed where inferred; dotted where concealed

Monocline, anticlinal bend — Axis located on steepest part of structure. Shorter arrow indicates steeper beds. Long dashed where approximately located; dotted where concealed

Overturned anticline — Location of trace of axial surface and dip direction of limbs; long dashed where approximately located; dotted where concealed

Overturned syncline — Location of trace of axial surface and dip direction of limbs; long dashed where approximately located; dotted where concealed

Small anticline — Showing bearing and plunge

Small syncline — Showing bearing and plunge

Minor fold — Axis and plunge of single fold

Dome

STRIKE AND DIP OF BEDDING

Inclined

Horizontal

Overturned — Where direction of younging is known

STRIKE AND DIP OF FOLIATION

Inclined

STRIKE AND DIP OF FRACTURES

Inclined

Vertical

Multiple — Point of observation where symbols join

KARST FEATURE

Area of collapse — Due to dissolution of underlying beds

Breccia pipe or sinkhole

Stream loss zone

OTHER FEATURES

af — Artificial fill — Compacted earth, indicated only where extensive

Wind Cave passages — Showing mapped subsurface extent in Pahasapa Limestone

Mine adit or cave

Prospect pit

Gravel pit