GEOLOGIC MAP OF THE WHITE HORSE PASS AREA, ELKO COUNTY, NEVADA

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SURFICIAL DEPOSITS AND CENOZOIC ROCKS

Qa **Quaternary alluvium** Unconsolidated alluvial deposits in major active drainages. Also includes sheet-wash deposits of coarse-grained granitic sand derived from the White Horse pluton that overlap the highstand Quaternary lacustrine deposits at the edge of Antelope Valley.

Qd **Quaternary sand-dune deposits** Unconsolidated, well-sorted, wind-blown sand concentrated in several patches southwest of White Horse Pass.

Qb **Quaternary lacustrine bar deposits** Poorly consolidated fine- to medium-gravel forming the conspicuous bar paralleling the highstand level of Pleistocene Lake Bonneville northward from Ferber Wash. Evidently formed by interaction between the highstand of Lake Bonneville and the sediment load from Ferber Wash, whose drainage basin within the map area and to the south and southeast is about 145 km^2.

Ql **Quaternary lacustrine deposits** Fine-grained lacustrine deposits and redeposited older alluvium locally forming minor beaches and bars associated with Lake Bonneville and the Pleistocene lake that occupied Antelope Valley. Inconspicuous except on aerial photographs.

Qo **Quaternary older alluvium** Alluvial fan deposits predating the highstands of Lake Bonneville and the Pleistocene lake in Antelope Valley; also thick, extensive talus and associated alluvial deposits in mountain valleys.

Qt **Quaternary tuff** Loosely consolidated, massive pumiceous tuff having a maximum thickness of a few meters. Contains layers of reworked tuffaceous sediment containing gravel; appears to be in the lowermost part of unit "Qo." Shown only where observed along the edge of White Horse Flat in the east-central sec. 20 and west-central sec. 29, T28N, R69E, and S½ sec. 10, T29N, R69E.

QTg **Quaternary-Tertiary gravel** Poorly sorted sedimentary breccia and gravel containing clasts up to several meters in long dimension. Partly to completely indurated. Matrix poor where best exposed in western part of outcrop area. Clast composition varies according to underlying rocks, so that in more western exposures recognizable clasts represent the Ely Limestone (IPe) and quartzite of the argillite member of the Chainman Shale (Mca); clasts in eastern exposures include fusulinid limestone derived from Permian unit A (PA) and igneous rocks from the Tertiary andesite unit (Ta). Distinctive clasts from units older than the argillite unit of the Chainman Shale (Mca), such as the Needle Siltstone Member of the Chainman Shale (Mcn) or the Guilmette Formation (Dg), were not observed. Although essentially unbedded and lacking in fluviatile deposits, at least in the more western and better exposed outcrops, crude layering results from differences in clast composition. In the low-relief, more eastern exposures, the light and dark bands apparent on aerial photographs are layers rich in limestone and in Tertiary andesitic rocks, respectively. Unit is confined to a 5-km-long band of outcrops in the low hills west of White Horse Mountain. Layering, as viewed on aerial photographs or from the distance, consistently dips 5-10° to the southeast. Exposed thickness exceeds 100 m.

Tr **Tertiary rhyolitic tuff** Vitroclastic rhyolitic tuff and flow-banded rhyolite containing conspicuous phenocrysts of biotite and less abundant white feldspar and quartz. Vitrophyric basal part of unit conspicuously perlitic in part. Unit is poorly exposed and confined to central sec. 35, T28N, R69E. Maximum exposed thickness about 300 m.

Tg **Tertiary gravel** Well-layered, steeply dipping gravel containing clasts up to boulder size derived both from the underlying Tertiary andesite unit and from pre-Tertiary rocks such as Permian limestone. No outcrops of this gravel were observed, but areas underlain by its surficial weathered debris are readily separated from areas of the compositionally similar, locally overlying, Quaternary older gravel by the regular, steep layering conspicuous on aerial photographs. Appears to concordantly overlie the Tertiary andesite unit (Ta). Apparent thickness at least several hundred meters but could be internally faulted. Confined to the southeast corner of the map area.

Ta **Tertiary andesite** Mainly dark agglomeratic andesite lahar deposits and interstratified andesite flows. Flow-banded dacite observed in a single outcrop just above the apparent base of the unit where it is interpreted to rest depositionally on red-stained (weathered?) limestone of unit PA (east-central sec. 34, T28N, R69E). Outcrops rare except in larger stream courses. Interstratified volcaniclastic fluviatile gravel observed in cut-bank exposures at one place (central sec. 26, T28N, R69E). Unit may be repeated by unrecognized faults, but it is at least several hundred meters thick. Restricted to the southeast corner of the map area, where it is part of a broad belt of older Tertiary andesitic rocks included by Coats (1987) in his unit "Ta," and shown by him as extending westward, south of the present map area, for about 50 km. Age probably Eocene; scattered, small outcrops of dacite having $^{40}Ar/^{39}Ar$ age of 39.80±0.1 Ma (Brooks and others, 1995) overlie unit PC as close as 16 km to the north of unit Ta exposures and 2 km north of the northeast corner of the White Horse Pass map area.

CENOZOIC OR MESOZOIC ROCKS

d **Dike rocks (Undated)** Dike rocks of silicic to intermediate composition and having granitic textures; mostly extensively altered. Although some of the mapped dikes are assigned a Tertiary age by Day and others (1987) and by Welsh (1994), most of these parallel or intrude pre-Tertiary faults or else they are silts that are folded along with the enclosing pre-Tertiary strata, and they are thus more likely Mesozoic—probably Jurassic—in age.

MESOZOIC ROCKS

Jg **Granitic rocks of the White Horse pluton (Upper Jurassic)** Granitic rocks ranging in composition from quartz-poor granodiorite to quartz-rich granite, but consisting predominantly of medium-grained, seriate-porphyritic quartz monzonite according to Mesain (1973), as paraphrased by Coats (1987). $^{40}K/^{39}Ar$ age on hornblende and biotite of 158±3 Ma reported by Armstrong (1970), recalculated as ca. 160 Ma (Miller and Hoisch, 1995). Geochemical, isotopic, and geobarometric data and interpretation given by Miller and Hoisch (1995).

Trt **Thaynes Formation (Lower Triassic)** Yellow-gray weathering, platy-parting, calcareous siltstone intergradational with nodular impure limestone. Restricted to a single exposure at the north margin of the map area (north-central sec. 4, T29N, R69E).

PALEOZOIC ROCKS

Permian strata

Permian strata in the White Horse Pass area and immediately to the north, at and near Ferguson Mountain, have customarily been assigned, in ascending order, to the Ferguson Mountain Formation, Pequop Formation (or Arcturus Formation), Loray Formation (sometimes included in the Pequop or Arcturus Formations), Kaibab Limestone, Plympton Formation (usually including or treated as an equivalent of the Phosphoria Formation), and Gerster Limestone (Berge, 1960; Steele, 1960; Coats, 1987; Gallegos and others, 1991; and Welsh, 1994). Equivalents of the Gerster and much of the Plympton were not observed in the map area. Among the other units, discounting assignments based on interpreted age or regional correlations, the lithologic basis for separating the various formations is for the most part vague. Neither sedimentologically based stratigraphic study nor detailed maps (other than that by Berge, 1960, which locates the upper and lower boundaries of his Ferguson Mountain Formation on Ferguson Mountain) are available to aid in recognizing the successive named units. Revision of the Permian stratigraphy, utilizing modern concepts such as sequence stratigraphy, would necessarily include exposures outside the present map area and is beyond the scope of the present study. For these reasons, Permian strata in the White Horse Pass area are assigned to utilitarian map units designated simply as Permian unit A, unit B, and unit C.

For characterization of the Permian units and the other, older carbonate rock units in the map area, the concepts and terminology of sequence stratigraphy are regarded as essential in a descriptive sense. For an explanation of sequence stratigraphy see, for example, Van Wagoner and others (1988).

PC **Permian unit C** Dolostone and limestone. Mostly coarsely crystalline eogenetic secondary dolostone; some limestone preserved locally near base. Lower part of unit C contains several meters of continuous, resistant, mainly medium-thick chert layers that form cuesta-like exposures. Evaporitic dolomudstone observed in one place relatively high in unit. Large productid brachiopods near base and silicified shell fragments higher in section attest to more open-marine deposition than the underlying supratidal rocks of Permian unit B; the base of unit C thus represents a stratigraphic sequence boundary. Among the stratigraphically highest rocks of unit PC is poorly exposed dark sandstone cropping out at one place on north side of Dead Cedar Wash (NW¼ NE¼, sec. 4, T29N, R69E). At least the lower part of unit C corresponds to the Kaibab Limestone as recognized in the area by previous authors. Higher parts of the unit may correspond to their Plympton Formation. Exposed thickness exceeds 100 m. Within the map area crops out only in the Ferguson Mtn. Quadrangle.

PB **Permian unit B** Dolomudstone and sandstone. From scattered outcrops and float, unit includes evaporitic dolomudstone, impure dolomudstone, and dolomitic siltstone or fine-grained sandstone. Poor exposure of unit B within the map area precludes observing the stratigraphic succession of the different rock types. Fine-grained sedimentary breccias composed of dolomudstone and the occurrence of chalcedony nodules and stringers within dolomudstone indicate original presence of evaporites; gypsum is reported nearby at Ferguson Mountain (Berge, 1960). Some dolomudstone is microbially laminated. Dolomitic siltstone or sandstone is either massive or herringbone cross-stratified on a small scale. Unit B is interpreted as a supratidal and tidal-flat deposit. Maximum estimated thickness about 200 m. Unit corresponds to the Loray Formation or part of the Arcturus Formation as applied previously in or near the map area. Permian unit B crops out only in the part of the Ferguson Mtn. Quadrangle included within the map area.

PA **Permian unit A** Limestone, sandstone, and dolomudstone. Permian unit A is a thick succession that is incompletely everywhere within the map area and contains repetitive lithologic units such as cherty massive limestone. Consequently, its characterization is both complicated and partly interpretive. It consists of peritidal cyclic parasequences ranging from a few to a few tens of meters in thickness. Basal parts of parasequences are massive, cliff-forming, commonly cherty, limestones overlain by more thinly and well-bedded limestones which in the more heterogeneous parasequences are in turn overlain by impure limestone, calcareous siltstone and fine-grained sandstone, or lime mudstone and dolomudstone, some of which is microbially laminated. Massive limestone units are mainly bioclastic packstones and wackestones. Many lack conspicuous crinoidal bioclasts, although crinoidal grainstones and packstones form part or all of some massive limestone units. In the overlying bedded limestone, impure limestone, and calcareous sandstone, fusilinids are common, in places occurring in rock-forming abundances.

The apparently most complete section of unit A within the map area is exposed in the hills a few kilometers southeast of White Horse Mountain. Here, unit A overlies the Ely Limestone, but its upper part is not exposed.

This section includes one complete third-order stratigraphic sequence and the lower part of another, the sequence boundary within unit A being at about the 6600-foot topographic contour east of elevation point 6743 on the crest line of these hills. The lower sequence is about 650 m thick and is distinguished from the higher in having supratidal desiccated lime mudstone or dolomudstone at the tops of individual parasequences. Within the bedded limestones, above the massive, basal limestones of the parasequences, ramose bryozoan fossils, occasionally associated with brachiopod shells, commonly occur in beds stratigraphically lower than those containing fusilinids, which occur to the exclusion of other megascopic fossils. Within the intra-parasequence succession of rock types, fusilinids thus evidently characterize the most evaporitically restricted fossiliferous rocks. Higher parts of the parasequences are unfossiliferous, partly supratidal deposits. In the lower part of the lower sequence within unit A, massive chert-stringer limestones, commonly crinoidal grainstones and packstones, tend to predominate the section; higher and near the top of the sequence massive limestones are thinner and non-bioclastic impure carbonate rocks and pale yellowish-gray dolomudstones attain thicknesses of 5 to 10 m in some parasequences. The lower sequence within unit A apparently is preserved only in the hills east and southeast of the White Horse Mountain massif where it overlies the Ely Limestone which forms the lower part of the hanging wall of the Ferguson detachment fault (see accompanying text).

In the overlying, incompletely exposed, upper third-order sequence within unit A, massive, more or less cherty, partly bioclastic gray limestones forming the lower parts of the included parasequences are characteristically separated by intervals of grayish-orange to yellowish-brown, commonly fusilinid bearing, fine-grained calcareous sandstone or impure limestone. Solitary or colonial corals occur sporadically in the massive bioclastic limestone units. Where exposed within the map area above the Ely Limestone in the hills southeast of White Horse Mountain, less than 100 m of this upper sequence is exposed. However, in the Ferber Hills and in the part of the map area within the Ferguson Mtn. Quadrangle, where unit A directly overlies the Ferguson detachment (see text), most of unit A apparently consists of the upper sequence, partial sections of which exceed 1,000 m in thickness if not repeated by unrecognized faults. The upper sequence of unit A, together with Permian unit B, may define a complete third-order stratigraphic sequence. The total thickness of Permian unit A probably exceeds 1,500 m. The unit corresponds to the rocks in the general area assigned to the Ferguson Mountain, Pequop, and Arcturus Formations by previous authors.

IPe **Ely Limestone (Pennsylvanian)** Limestone, sandy limestone, quartzite, and dolomudstone. A peritidal cyclic succession dominated by units of massive, more or less cherty, limestone that form the lower parts of parasequences. The limestone units are commonly crinoidal grainstones or crinoid-bioclast packstones and wackestones, except in the stratigraphically higher parts of the Ely where massive units of lime mudstone or sparsely bioclastic lime wackestone prevail. Many of the limestones contain quartz sand or are streaked with quartz sand, exhibiting conspicuous, centimeter-scale, tabular cross-stratification. Some massive limestones grade up into fine- to medium-grained calcareous sandstone or, locally, quartzite in units up to 12 m thick. Less sandy parasequences may be capped with desiccated lime mudstone or dolomudstone, some of which is microbially laminated.

Compared to the equally cyclic and lithologically similar Permian unit A, the Ely Limestone is differentiated by having more abundant crinoidal grainstones, more and coarser quartz sand as a component of the limestones or as discrete units, larger scale cross-stratification in the lower parts of the parasequences, and in general having the aspect of more open marine and energetically deposited strata. Megascopically recognizable fusilinids were not observed in the Ely Limestone. The maximum exposed thickness of the Ely within the map area is 800-1,000 m.

Chainman Shale (Mississippian)

The Chainman Shale within the map area is divided into four lithologically distinct members, in descending order, the: argillite member, siltstone member, White Horse Pass limestone member, and the Needle Siltstone Member. Apparently complete sections of the White Horse Pass limestone and Needle Siltstone members are locally preserved, but where the siltstone member is preserved at all within the map area, its upper contact is an attenuation fault. The internally much deformed argillite member is bounded below by this same attenuation fault and above by the Ferguson detachment fault; locally it is completely cut out beneath the Ferguson detachment.

Mca **Argillite member** The argillite member is preponderantly highly fractured black or very dark olive-gray argillite. In most places bedding is expressed only by occasional, discontinuous, thin interbeds of yellowish brown dolomitic sandstone or quartzite, or more rarely of dark, impure, dense limestone. Boldly outcropping packets of medium- to thick-bedded, light brownish-gray quartzite occur locally, in the structurally, if not stratigraphically higher parts of the unit. Quartzite beds commonly have tabular cross-stratification and are current rippled on their top surfaces. Most of the bedding and minor-fold attitudes shown for the argillite member on the map are those of quartzite beds.

The argillite unit forms an internally deformed mass between the Mesozoic attenuation fault at its structural base and the Tertiary-Ferguson detachment fault; neither the stratigraphic top nor bottom of the member is preserved. The structural thickness of the argillite member varies from 0 to several hundred meters within the map area.

Mcs **Siltstone member** The siltstone member is restricted to stratigraphically thin exposures that crop out locally beneath the attenuation fault at the structural base of the argillite member of the Chainman Shale. North of White Horse Pass it consists of up to several meters of pale-red to light brown, platy to slabby weathering calcareous siltstone bearing abundant bedding-parallel, irregularly sinuous, feeding tracks. Where the preserved thickness of the member is greatest, about 3 km southeast of White Horse Pass, it is internally folded, cut by thin dikes, and poorly exposed. Here, its maximum thickness is only a few tens of meters, and in addition to yellow-brown, pale-red, and gray calcareous siltstone it contains some laminated siliceous shale and a few isolated beds of lime mudstone. At one place, float of a silicified, coarse-grained, phosphorite lag deposit, probably no more than several centimeters thick, occurs well above the base of the member.

Mcw **White Horse Pass limestone member** The major part of this member is regularly medium- to thick-bedded, internally featureless lime mudstone characteristically weathering to medium dark gray (N4 of the Geological Society of America Rock-Color Chart). Bed partings within the limestone are distinct and marked by siliciclastic impurities or thin intercalations of yellow-brown to pale-red calcareous siltstone. Rarely, up to a few meters of calcareous siltstone or slabby weathering impure limestone are interbedded with the ubiquitous lime mudstone. Near or at the base of the member are one or two beds, up to 1.5 m thick, of crinoidal grainstone, some of which display dune-like cross stratification having generally southward sloping foresets after bedding is restored to horizontal. The stratigraphically highest 10 m or so of the member is also characterized by drifts of crinoidal bioclasts on the surfaces of lime-mudstone beds and by beds of crinoidal packstone and grainstone. The lime mudstone forming the bulk of the member commonly contains conspicuous anastomosing, solution(?) cleavage surfaces having sub-millimeter spacing. This cleavage mostly parallels bedding. Maximum structural thickness of the internally deformed White Horse Pass limestone member is about 100 m.

The limestone of White Horse Pass, as informally named by Day and others (1987), is equivalent to the Ochre Mountain Limestone of Nolan (1935) in the Gold Hill mining district about 30 km east of the White Horse Pass map area. However, this prior name is not used herein because the typical example of the Ochre Mountain is not only intensely fractured, but also pervasively dolomitized and silicified, making lithologic comparison uncertain. Aside from its altered nature, the Ochre Mountain also appears to be more crinoidal within the main body of the unit and to contain less intercalated siltstone than does the White Horse Pass limestone. Welsh (1994) assigned the member to the Camp Canyon Limestone, another correlative but lithologically distinct unit in westernmost Utah.

Mcn **Needle Siltstone Member** Platy to flaggy weathering, dolomitic or calcareous siltstone and very fine-grained sandstone, characteristically light brown to yellowish orange, more rarely pale red weathering. Locally, especially relatively low in the section, bedding-parallel, irregularly sinuous burrows are abundant. Dolomite is entirely secondary in subhedral to euhedral crystals which may constitute more than half the rock volume, in which case the dolomitic siltstone grades into silty dolostone. In addition to 50-100 µm quartz grains, detrital minerals include a few percent of feldspar and mica. Obliately spheroidal phosphatic nodules occur sparsely throughout the unit.

Most of the Needle Siltstone within the map area has an attenuation fault essentially at its base. Near the base, float of peloidal phosphorite beds up to 2 cm thick, black chert, gray platy mudstone, and lime mudstone are characteristic. Where the member rests depositionally on the Joana Limestone, a 0.5 m-thick bed of featureless lime mudstone crops out several meters above the base. East of White Horse Mountain, where the Needle Siltstone section is complete, its thickness is about 100 m.

The Needle Siltstone in the map area is equivalent to the Woodman Formation of Nolan (1935), named in the Gold Hill mining district about 30 km to the east. Despite the priority of Nolan's name, the unit is referred herein to the better-known Needle Siltstone Member, following the usage of Day and others (1987) in the White Horse Pass area. The basal phosphatic part of the member is recognized as a separate unit beneath Needle Siltstone and referred to as the "Delle member" by Welsh (1994), but regionally there is no consistent means of recognizing a lithic boundary between the Delle and Needle members away from the type section of the Delle in north-central Utah.

Joana Limestone (Mississippian)

The Joana Limestone is divided into an upper and a lower member, but because of attenuation faulting, no continuous section of them occurs in the map area. Along the east margin of White Horse Mountain, the attenuation fault that separates the two members of the Joana progressively cuts out the lower member in its footwall as it is traced southwestward. Farther north, the upper member is completely removed from the hanging wall of this same fault.

Mju **Upper member (Lower Mississippian)** Evenly and rythmically medium-bedded, medium dark-gray limestone. Commonly conspicuously crinoidal, but ranging from crinoidal grainstone to lime mudstone. Fine-grained beds characteristically have siliciclastic impurities and crinoidal bioclasts on parting surfaces of bedding. Bedding normally graded in part. Interpreted as a tempestite, i.e., a deep-subtidal storm deposit. The upper member of the Joana along the southwest flank of White Horse Mountain is largely or wholly replaced by jasperoid.

The upper member of the Joana in the map area generally resembles the upper member of the *neotypa* Joana Limestone at Ward Mountain in the Egan Range and the "Harris Canyon member" of the Joana of Crosbie (1997; Silberling and others, 1997), named for exposures in the White Pine Range.

Mjl **Lower member (Lower Mississippian)** Mostly massive, solution-compacted, neomorphosed limestone having thick stylolitic parting. Sparse crinoidal bioclasts preserved locally; dense limestone appear to have been pellet-calcisphere wackestones and packstones, some of which are faintly mottled. Rare megafossils include large gastropods and, in one place, solitary corals. Oncolites occur at two levels in the lower Joana east of Sugar Loaf Peak. Here, the lowest few meters of the member retain some of the rhythmically thin- and medium-bedded character distinctive of the basal lithosome (unit MO.Rh.Lm of Silberling and others, 1995) of the Joana regionally, and these beds rest depositionally on the Guilmette Formation. North of White Horse Pass the basal meter or so of the Joana is planar-laminated limestone, and the contact with the underlying Guilmette is a karst surface having more than a half meter of relief. This is especially well displayed in the west-central NW¼, sec. 24, T29N, R68W. Conodonts recovered from two samples collected at about the same stratigraphic level within the lower Joana in the E½, sec. 26, T29N, R69W range in age from early Famennian to Kinderhookian (R.G. Stamm, written commun., 1994) and are evidently largely reworked from strata that were eroded prior to deposition of the Joana unconformably upon the Guilmette Formation.

Dg **Guilmette Formation (Devonian)** Limestone, dolostone, and quartzite. A cliff-forming succession of shallowing-upward, peritidal cycles or parasequences, each a few meters to tens of meters in thickness. The component rock types within the parasequences vary through the section, but an idealized complete parasequence contains from the bottom upwards: (1) dark gray limestone, some of which contains low-diversity shelly faunas of pelecypods, gastropods, or brachiopods; (2) gray limestone containing rounded heads of stromatoporoids up to 20 cm in diameter; (3) gray limestone containing spaghetti-like masses of the coelenterate *Amphipora*; (4) gray lime mudstone or fossils bull streaked and mottled with brown-gray weathering impure dolostone; and (5) light-gray-weathering dolomudstone ("penecontemporaneous" dolostone), some of which has microbial lamination or, more rarely, low-amplitude stromatolites. Some parasequences are mainly dolomitic, whereas others are primarily composed of limestone. White to light brown dolomitic quartzose sandstone or quartzite in units up to 20 m thick occurs sparsely in the dolostones or above them, in which case they cap the parasequences. Quartzite is more conspicuous in the lower part of the Guilmette as exposed. Some of the thicker quartzite units, or sets of quartzite units in successive parasequences are traceable for several kilometers, but most quartzite units are laterally discontinuous. The original limestones forming the lower parts of parasequences may be replaced with featureless, light-gray to white, sugary, secondary dolostone, for the most part apparently of eogenetic (Nichols and Silberling, 1980) replacement origin.

In the isoclinally folded Guilmette marble within the contact zone of the White Horse pluton, the strongly asymmetric succession of different rock types forming the peritidal parasequences provides a reliable top vs. bottom criterion, along with preferred orientation of shelly fossils according to shape and geopetal deposits within bivalve and gastropod shells. Variation in the relative representation of the different rock types within cycles, and trends of systematic variation in cycle thicknesses, suggest that more than one third-order stratigraphic sequence is represented by the exposed part of the Guilmette Formation. Maximum exposed thickness is only several hundred meters; much of the lower part of the formation is not exposed within the map area.

See accompanying text for references and a description of the structural evolution of the map area.

Contact Dashed where approximately located.

Trace of bedding Shown locally for structural control.

Projection of bedding above ground level On cross section B-B'.

Normal fault Dashed where approximately located; dotted where concealed on map or projected above ground level on cross sections; bar and ball on downthrown side; arrow indicates measured dip.

Strike-slip fault Dashed where approximately located; dotted where concealed.

Ferguson detachment fault Dashed where approximately located; dotted where concealed on map or projected above ground level on cross sections; open rectangles on hanging wall.

Dondon low-angle normal fault Dashed where approximately located; dotted where concealed. Ticks on hanging wall.

Mesozoic attenuation fault Dashed where approximately located; dotted where concealed on map or projected above ground level on cross sections; solid rectangles on upper plate.

Thrust fault Dashed where approximately located; dotted where concealed; barbs on upper plate.

Axial traces of F_1 folds showing plunge Anticline, syncline, overturned anticline, and overturned syncline. Arrows indicate dip of limbs.

Axial traces of F_2 and F_3 folds Dip symbols as with F_1 folds.

Jasperoid Replacement of carbonate rocks, mainly those of Mju. Labelled Mju where remnants of this unit are preserved.

Sill swarms Propylitized granitic-textured sills too thin to be mapped separately. Where exposures of these sills are sufficiently large to show on map, they are assigned to unit d.

Strike and dip of beds Inclined, overturned, vertical, and horizontal.

Strike and dip of beds Facing direction, as marked by ball, determined from depositional features; inclined, overturned, and vertical.

Strike and dip of beds Generalized where variable and estimated from aerial photographs; inclined and vertical; facing direction marked by ball.

Strike and dip of flow banding in Tertiary volcanic rocks Inclined and generalized where variable.

Strike and dip of solution-cleavage foliation in Mcw and grain-shape foliation in Dg Inclined and vertical.

Strike and dip of bedding and foliation coincident Foliation in plane of bedding; inclined, overturned, and vertical.
Inclination of foliation and bedding different; bedding vertical, facing direction marked by ball.

Strike and dip of fracture cleavage Inclined, vertical.

Plunge of elongation lineation May be combined with symbols for foliation or bedding.

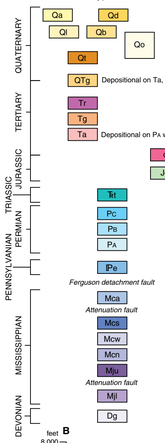
Strike and dip of planar veins Inclined and vertical. Multiple, planar, parallel calcite veins interpreted as flexural-extension features parallel to axial surfaces of F_2 or F_3 folds.

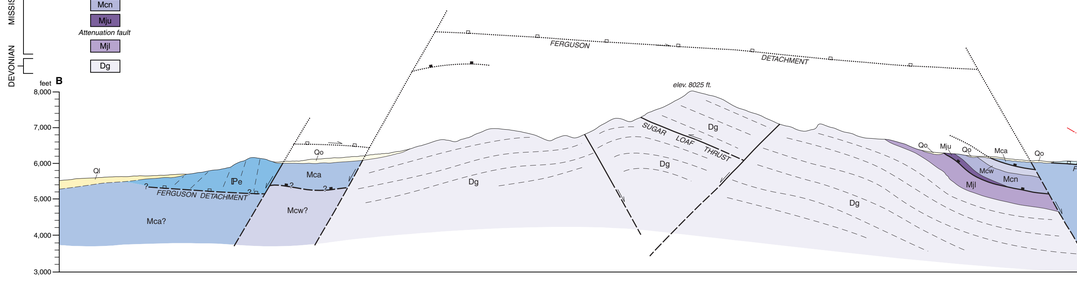
Trend on bedding surface of en echelon calcite-vein gash array Plane parallel to gash array roughly orthogonal to gently dipping bed; arrow shows sense of shear.

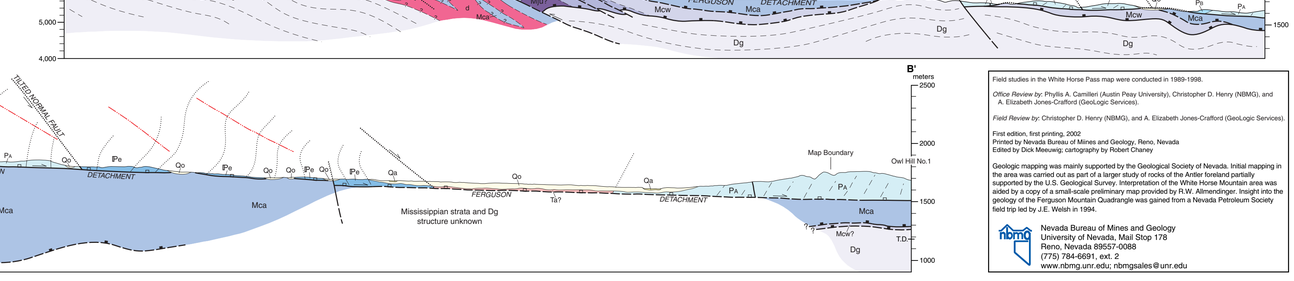
Trends on bedding surface of conjugate en echelon calcite-vein gash arrays Intersection of planes parallel to arrays interpreted as the Y axis of flexural-extension strain ellipsoid. Sense of strike-slip then defines extensional (X) and contractional (Z) directions of flexural extension.

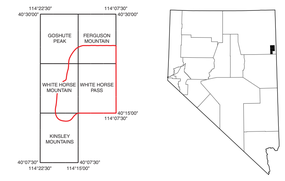
Trend and plunge of minor folds Anticline, syncline, multiple, and horizontal.

Trend and plunge of fold axis and dip and strike of axial surface Plunge of axis inclined, horizontal.









Scale 1:24,000

0 0.5 1 kilometer

0 0.5 1 mile

0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 20 FEET, east of 114°15'
CONTOUR INTERVAL 10 METERS, west of 114°15'

Base map: U.S. Geological Survey White Horse Pass, Nevada 7.5' Quadrangle, 1972 Digital Raster Graphic (DRG); White Horse Mountain, Nevada 7.5' Quadrangle, 1982 Digital Raster Graphic (DRG); Goshute Peak, Nevada 7.5' Quadrangle, 1982 Digital Raster Graphic (DRG); Ferguson Mountain, Nevada 7.5' Quadrangle, 1972 Digital Raster Graphic (DRG); and Kinsley Mountains, Nevada 7.5' Quadrangle, 1982 Digital Raster Graphic (DRG)

Field studies in the White Horse Pass map were conducted in 1989-1998.

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