GEOLOGIC MAP OF MILLER MOUNTAIN AND COLUMBUS QUADRANGLES, MINERAL AND ESMERALDA COUNTIES, NEVADA

By

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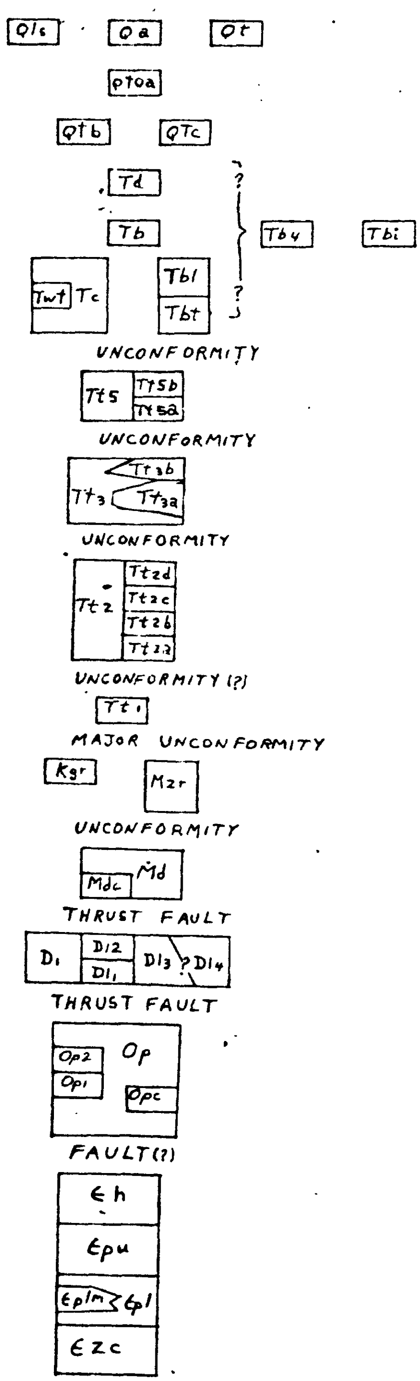
MAP EXPLANATION

CORRELATION OF MAP UNITS



Contact

High-angle fault
Dashed where inferred or approximately located
Queried where highly uncertain
Dotted where concealed
Ball on downthrown side

Thrust fault
Dashed where approximately located
Sawteeth on upper plate

Anticlinal axis
Arrow indicates direction of plunge
Dashed where approximately located
Queried where highly uncertain

Synclinal axis
Arrow indicates direction of plunge
Dashed where approximately located
Queried where highly uncertain

Strike and dip of bed

Strike of vertical bed

Strike and dip of overturned bed

Fossil locality

Indefinite boundary between Opl and Op

DESCRIPTION OF MAP UNITS

(Petrography of Cenozoic rocks by P. T. Robinson)

Qls LANDSLIDE DEPOSITS

Qa ALLUVIAL DEPOSITS

Qt TALUS DEBRIS--Shown only where obscures contacts

QToa OLDER ALLUVIAL DEPOSITS

QTb BASALT--Medium gray, generally olivine bearing, vesicular and nonvesicular, locally includes andesite. Occurs in association with only partly eroded cinder cones and in flows that conform in part with present-day topographic features. Probably not consistently separated from Tb, Tbu, or Tbi

QTc BASALT CINDER--Reddish-brown cinder; forms cinder cones

Td DIATOMITE AND DIATOMACEOUS MUDSTONE--White chalky diatomite and white, very light gray, and light-greenish-gray diatomaceous mudstone. Evenly laminated to thin bedded. Includes some cross-laminated sandstone

Tb BASALT--Light- to dark-gray vesicular olivine basalt and basaltic andesite to trachyandesite. Generally about 30 to 45 m thick. Considered equivalent to Tb of Crowder and others (1972) and to QTb of Robinson and Crowder (1973) directly south of the Miller Mountain and Columbus quadrangles. Some rocks mapped as Tab by Robinson and Crowder (1973) in secs. 29, 31, 32, and the southwest part of sec. 33, T. 2 N., R. 34 E., are considered here to be equivalent to rocks mapped as Tb and not related to rocks elsewhere mapped as Tab by Robinson and Crowder (1973)

Tbu BASALT, UNDIVIDED--Light- to dark-gray, vesicular and nonvesicular olivine basalt. Includes andesite in Candelaria Hills in northwest part of Columbus quadrangle. Generally 15 to 60 m thick. Locally difficult to distinguish from intrusive basalt included in Tbi

Tbi IRREGULAR INTRUSIVE BASALT MASSES AND DIKES--Locally difficult to map separately from lava flows of Tbu

Tbl SEDIMENTARY BRECCIA--Composed of only slightly rounded mafic lava fragments. All gradations in grain size from fine sand composed of rock fragments and individual minerals to angular boulders 1 m in diameter. Most lava fragments are vesicular. May be in part a mudflow or lahar. Some parts may be fluvial. No internal stratification noted. About 30 to 60 m thick

Tbt SEDIMENTARY BRECCIA CONTAINING LARGE BLOCKS OF TUFF--Sedimentary breccia composed of blocks of tuff (mostly unit Tt5) and of sparse mafic lava, set in matrix of sand, granules, and small pebbles of tuff, lava, chert, and argillite. Blocks of Tt5 commonly a meter across and rarely about 15 m in maximum diameter. Unit includes a minor amount of dusky yellow conglomerate composed of granules, pebbles, and cobbles of vesicular and nonvesicular basalt and chert set in a fine to coarse sand matrix. Conglomerate is evenly laminated to very thin bedded and generally occurs at base of unit. Isolated outcrops of sedimentary breccia of uncertain assignment occur in central western part of Columbus quadrangle and central eastern part of Miller Mountain quadrangle and are assigned to Tbt. These breccias occur in association with intrusive masses of basaltic rock, and probably represent local vent breccia rather than part of a widespread sedimentary unit

Tc CONGLOMERATE--Composed of rounded granules to boulders of welded tuff (commonly of unit Tt5), mafic vesicular lava, granitic rock, quartzite (Ordovician?), and other rock types in sand matrix. Contains several 1 to 15 m units of poorly welded, nonresistant ash-flow tuff; one ash flow mapped separately (Twt)

Twt ASH-FLOW TUFF--Very light gray, moderately crystal-rich, sanidine and sparse biotite sparse volcanic rock fragments, densely welded, weathers to form ridge. Sparse to common flattened pumice

Tt5 CANDELARIA TUFF OF SPEED AND COGBILL (1979)--Ash-flow tuff, pale-red to grayish-red, 18 percent crystals, plagioclase, sanidine, quartz in approximate proportions 2:2:3, sparse biotite; common flattened pumice, eutaxitic structure well-developed, densely welded, vitrophyre near base. Generally only one cooling unit; in northwest of Columbus quadrangle consists of two well-defined cooling units (Tt5a and Tt5b). Weathers to form conspicuous cliff and underlies irregular upland areas. Generally about 60 m thick. On northwest side of Miller Mountain occurs in part as rubbly debris that is difficult to distinguish from outcrop material. As mapped, most of this debris is considered to be outcrop material or debris only slightly moved from its original position. Includes Tvl7, Tvl8, Tvl9 of Page (1959)

Tt5b UPPER COOLING UNIT OF Tt5

Tt5a LOWER COOLING UNIT OF Tt5

Tt3 ASH-FLOW, SEDIMENTARY TUFF, AND LAHAR--Generally 60 to 120 m thick. Forms debris covered slopes. Mapping of subunits was not attempted in much of the map area, because debris conceals contacts and separation of units is difficult without detailed study

Subunits in unit Tt5 consist, in descending order, of (1) lahar, locally mapped as unit Tt3b, (2) sedimentary tuff, (3) Belleville Tuff of Speed and Cogbill (1979), mapped as unit Tt3a, and (4) tuff of Eastside mine. The sedimentary tuff and tuff of Eastside mine were not mapped as separate units. Description of subunits follows:

Tt3b Lahar, composed of slightly rounded fragments of mafic lava as much as 1 m in diameter set in a fine- to coarse-sand matrix. Six to 12 m thick. Mapped separately only in the northwest part of the Columbus. Also recognized in the northwest part of the Miller Mountain quadrangle, but here it was not mapped as a separate unit and is included in undivided Tt3

Sedimentary tuff--Poorly bedded to well-bedded tuff, largely reworked from tuff of Eastside mine. In places pumice fragments concentrated in thin layers. Locally contains thin lenticular layers of conglomerate composed mostly of clasts of Paleozoic rocks. Paleozoic clasts sparse or absent elsewhere. Overlies Tt3a, or tuff of Eastside mine where Tt3a is absent. Underlies lahar, or where lahar is absent underlies Tt5

Tt3a Belleville Tuff of Speed and Cogbill (1979)--Yellow-gray to light-gray, common moderate reddish-orange zones; 18 percent crystals, plagioclase (10 percent) and sanidine, quartz, biotite, pyroxene, and opaque minerals; 3 percent lithic fragments; abundant pumice; nonwelded to densely welded black vitrophyre; generally two to three cooling units. Locally fills 30 to 60 m deep channels cut into tuff of Eastside mine; locally cuts completely through tuff of Eastside mine and rest on unit Tt2. Where unit fills channels, contains abundant vitrophyre as well as nonwelded ash-flow tuff. Discontinuous. Most extensively exposed in northern part of Miller Mountain quadrangle. Includes Tvl3, Tvl4, and Tvl5 of Page (1959). As mapped, may locally include sedimentary tuff, conglomerate, and lahar elsewhere included in undivided unit Tt3 or in unit Tt3b

Tuff of Eastside mine--Very pale orange to pale-yellowish-brown; 15 percent crystals, plagioclase, sanidine, and quartz in approximate proportion 6:4:3, sparse biotite and opaque minerals; 5 percent lithic fragments as large as 5 to 8 cm in diameter composed of brown porphyritic lava, of aphanitic lava, and of sparse Paleozoic rocks. Common pumice. Mostly nonwelded or only slightly welded; rarely moderately welded. Consists of one cooling unit. Where moderately welded, forms a cliff; elsewhere forms a slope. Locally weathers to badlands topography. Same as unit 6 of Speed and Cogbill (1979)

In most places, tuff of Eastside mine constitutes about 50 to 75 percent of unit Tt3, but locally constitutes almost all of unit Tt3; in other areas, it is absent and all of unit Tt3 consists of sedimentary tuff. Rests unconformably on tuffs of unit Tt2 and is overlain by unit Tt3a, where that unit is present, and by sedimentary tuff elsewhere

ASH-FLOW TUFF

Tt2 — Ash-flow tuff, mapped as undivided tuff except in Candelaria Hills area in northern part of Columbus quadrangle where Tt2 is divided, in descending order, into units Tt2d, Tt2c, Tt2b, and Tt2a. Undivided Tt2 contains two to three cooling units, the uppermost of which appear to be unit Tt2d described below. Other tuff in unit Tt2 is probably mainly Tt2a, although Tt2b probably occurs in some areas. Locally contains thin sandstone and conglomerate layers. Units in Candelaria Hills consist of the following:

Tt2d — Metallic City Tuff of Speed and Cogbill (1979)--Ash-flow tuff, dark gray in lower part, light gray in upper part; 25 percent crystals, plagioclase, sanidine, and quartz in approximate proportions 14:3:4, 2.7 percent biotite, sparse hornblende and opaque minerals; 1.6 percent rock fragments; densely welded; conspicuous vitrophyre at base; cliff forming; about 30 to 50 m thick. Same as Tvl2 of Page (1959, fig. 9 and pl. 1)

Tt2c — Nonresistant welded and nonwelded ash-flow tuff, white to yellow-gray; 5 percent crystals of plagioclase, biotite, with minor quartz, sanidine, and magnetite; 5 to 6 percent fragments of andesite and welded tuff; fine-grained pumice is ubiquitous but coarse pumice lumps as large as 15 cm across are concentrated locally; small black obsidian chips scattered through unit; slope-forming; about 80 m thick; includes Tv7 and Tvll of Page (1959, fig. 9 and pl. 1) and is same as unit 4 of Speed and Cogbill (1979)

Tt2b Ash-flow tuff, yellowish-gray, weathers to form light-colored cliff; about 65 m thick. Consists of a lower and upper ash-flow tuffs. Lower ash-flow tuff, 10 percent crystals, plagioclase and lesser amounts of quartz, sanidine, biotite, and magnetite. Upper ash-flow tuffs, 20 percent crystals, plagioclase, sanidine, and quartz in approximately equal amounts. Upper ash-flow tuff includes Tv-5, Tv-6, and Tv-9 of Page (1959, fig. 9 and pl. 1) and is same as unit 3 of Speed and Cogbill (1979). Lower ash-flow tuff includes Tv-2, Tv-3, Tv-4 of Page (1959, fig. 9 and pl. 1) and is same as unit 2 of Speed and Cogbill (1979)

Tt2a Ash-flow tuff--Yellow-gray; 20 percent crystals, plagioclase and biotite, minor quartz, sanidine; 1 to 2 percent green hornblende in most specimens, most of which is altered to smectite(?); sparse flattened pumice; poorly to densely welded; generally weathers to "soft" white slopes. Locally rest on thin conglomerate separating it from underlying Ordovician Palmetto Formation. Same as Tv-1 of Page (1959, fig. 9 and pl. 1) and unit 1 of Speed and Cogbill (1979)

Tt1 ASH-FLOW TUFF--Pale-red; 7-8 percent crystals; plagioclase, sanidine, and quartz in approximate proportions 2:1:1; sparse biotite; 3-5 percent lithic fragments; mostly of black chert; sparse flattened pumice, densely welded (resembles rhyolite in places), discontinuous, small patchy outcrops, largest outcrop is 7.2 km west-southwest of Columbus in Columbus quadrangle

Kgr GRANITIC ROCK--Occurs 5 km southeast of Miller Mountain and about 2 km northeast of Columbus. Potassium-argon data indicate a 91.7- and 89.8-m.y. age on muscovite and biotite, respectively, from the granitic rock southeast of Miller Mountain and a 91.2-m.y. age on biotite from the granitic rock northeast of Columbus (Speed and Kistler, 1979)

Mzr FINE-GRAINED FELSIC INTRUSIVE ROCK--Age uncertain

Mc DOLOMITE AND MINOR AMOUNTS OF LIMESTONE--Dolomite, very pale orange to grayish orange, highly contorted and altered. Local dark-brown silicified zones. Limestone, medium-gray, crinoidal. Originally assigned to Permian Diablo Formation by Ferguson and others (1954). New fossil evidence indicates a Mississippian age (Poole and Sandberg, 1977; Speed and others, 1977); unit is no longer assigned to the Diablo Formation

Mcc Conglomerate with granules and pebbles of chert. One outcrop

DEVONIAN LIMESTONE, LIMY SANDSTONE, CALC-HORNFELS, AND CHERT. Includes following units:

Dl Sandy limestone. Generalized outcrop area. Contacts may be sedimentary or fault

Dl_4 Structurally contorted sequence of limestone, sandy limestone, chert, siltstone, shale, and siliceous hornfels that is 100 m or more thick. Appears to be in stratigraphic continuity with Dl_3. Some probable phosphatic material in lower 15 m of unit

Dl_3 Siliceous shale, chert, and siliceous calc-hornfels in lower 110 m and mostly limestone and sandy limestone in upper 150 m. Rocks in the lower 110 m are somewhat similar lithologically to unit Dl_1, and rocks in the upper 150 m are almost identical to unit Dl_2. Rocks of Dl_1, Dl_2, and Dl_3 may be equivalent and repeated by faulting

Dl_2 Limy quartz sandstone and sandy limestone, pellitoid limestone, fine-textured limestone, and sparse chert, siliceous hornfels, and quartzite. About 150 m thick. The most distincitve part is the limy quartz sandstone and sandy limestone which occur in 1- to 16-m-thick gravity flow layers. The limy quartz sandstone and sandy limestone consist of rounded to well-rounded, fine to coarse, and in places very coarse, grains of quartz and quartzite, sparse amounts of fine- to medium-grained K-feldspar (including some microcline) calcite pelletoids and organic fragments, and angular chert fragments as large as 50 mm, all set in fine calcite matrix. Poorly defined grading occurs in some layers; the grading is coarse sand at the base to fine at the top. Generally, such grading is difficult to detect and many units appear lithologically uniform throughout. Typically, gravity flow units are structureless except for the top 10 to 60 cm which contains poorly defined small-scale cross laminae or parallel laminae. Very poorly defined and problematical dish structure occurs locally within the gravity flow units. The chert clasts occur throughout most units and only rarely can a concentration of these clasts be noted at the base of a gravity flow unit

Dl_2 also contains current deposited limestone and sandy limestone that is cross-stratified, parallel laminated, or contains sets of climbing megaripples. These rocks appear to be an interrelated series of sedimentary types, and occur in well-defined sets that are not gradational into gravity flow units. The parallel laminated limestone is generally pelletoidal whereas the cross-laminated limestone consist of a mixture of very fine to fine grained quartz sand mixed with fragments or calcitic organic material, all set in a finer grained calcite matrix. Cross-strata are small scale and occur in 2 to 8 cm thick sets. In some layers the cross-strata grade upward into climbing megaripples

Megaripples also occur in limestone layers that do not contain cross-strata. In these, the wave height is about 0.4 cm and the wave length about 45 cm. Convoluted laminae occurs rarely in the current deposited limestone

Very finely laminated and fine-textured to sandy limestone occurs in layers a few millimeters to about 2 m thick interstratified with the sets of gravity flow deposited material and current deposited limestone and sandy limestone. These very finely laminated limestone apparently represent deposition in quiet water. Locally they contain animal burrows

Dl_2 also contains contorted layers which generally ranged in thickness from 1.5 to 7 m. These layers consist mostly of quiet water laminated limestone and thin sets of gravity flow sandy limestone. The contorted layers probably formed by slumping

Dl_1 Yellowish-gray to light-gray, evenly laminated to very thin bedded siliceous calc-hornfels interstratified with minor amounts of medium-gray siliceous hornfels and shale and dark-gray chert, 150 m thick

Op PALMETTO FORMATION--Phyllitic to hornfelsic shale, limestone, and chert. Includes following mapped units

Opc Calc-hornfel and minor amounts of phyllitic shale and chert. Forms ledges

Op_2 Radiolarian chert (70 percent, all percentages approximate), hornfelsic shale (25 percent), siliceous calc-hornfels and siliceous hornfels (5 percent), and quartzite (1 percent). Similar to Op_1 except contains a greater amount of chert and small amount of quartzite, some of which may be graded. A 2-m-thick layer of bedded barite has been prospected in unit about 5 km east-northeast of Miller Mountain. Unit is about 600 m thick

Op_l Predominantly dark gray laminated phyllitic to hornfelsic shale; contains abundant trace fossils. Graptolites are common. The top 80 m consist predominantly of dark-gray, very thin bedded radiolarian chert, with minor amounts of hornfelsic shale and a few layers of limestone and calc-hornfels at top. The upper contact (possibly a thrust) is well defined and the lower contact is not. The lower part of the unit is within a structurally complex sequence where shale of the unit are adjacent to similar appearing but much younger graptolitic shales. The minimum thickness of the unit appears to be about 450 m

Ꞓh HARKLESS FORMATION--Siliceous hornfels, dark-gray to brownish-gray, weathering dark yellowish brown, very thin bedded, top not exposed, exposed thickness about 300 m (Wilson, 1961). Trilobites common in lower 10 m and indicate an Early Cambrian age (Wilson, 1961; Nelson, 1976)

POLETA FORMATION. Divided into two units:

Ꞓpu UPPER UNIT--Marble, very pale orange and light- to medium-gray, laminated to thin bedded. About 180 m thick (Wilson, 1961). Top 6 m of unit locally contains interlayered siliceous hornfels layers with Early Cambrian trilobites (Wilson, 1961). Archeocyathids occur rarely (Moore, 1976)

Ꞓpl LOWER UNIT--Calc-silicate hornfels, light- to medium-gray and greenish-gray, weathering pale yellowish brown to grayish orange, laminated, occurs in very thin layers. Siliceous hornfels, dark-gray, laminated, interstratified in very thin to thin sets with the calc-silicate hornfels. Unit about 200 m thick. Sparse Early Cambrian trilobites and archeocyathids (Wilson, 1961)

Ꞓplm Marble, very pale orange and light-gray, laminated, occurs in lenticular units. Lenticularity of marble may be due in part to original depositional lenticularity, but much is probably due to tectonic squeezing of the incompetent marble units. Only major marble units shown. Contents as mapped may be sedimentary or fault. Marble of upper and lower units of Poleta Formation are similar and may not everywhere have been properly distinguished

ЄZc CAMPITO FORMATION--Siliceous hornfels, dark-gray to greenish-gray, laminated to very thin bedded, base not exposed, exposed thickness about 550 m (Wilson, 1961). Early Cambrian trilobites occur in top 15 m of unit and rarely as much as about 380 m below the top of the formation (Wilson, 1961)

FOSSIL LOCALITIES

[Locations to nearest 10 seconds. F1-F14, identified by W. B. N. Berry; F15 and F19, identified by R. J. Ross, Jr.; F16-F18, identified by A. E. Harris]

Locality shown in map	Description of collection
F1	USGS Clln. D2479CO (Field No. 1-151-10J) Palmetto Formation. Long 118° 10'40" W.; lat 38° 7'0" N. Climacograptus sp. Diplograptus? sp. Age: Middle-Upper Ordovician
F2	USGS Clln. D2480C) (Field No. 1-119-1J) Palmetto Formation. Long 118° 13'0" W.; lat 38° 7'0" N., Miller Mtn. 7½' quad., Nevada dichograptid diplograptid (possibly climacograptid) Age: Probably early part of Middle Ordovician. Could be up to C. bicornis zone. Best estimate zone 8-12 span. (zones 7-10 of Elles and Wood).
F3	USGS Clln. D2481CO (Field No. 1-162-46J) Palmetto Formation. Map unit 1 of Stewart. Long 118° 7'20" W., lat 38° 3'40" N. Columbus 7½' quad., Nevada. Climacograptus Bicornis Dicellograptus Intortus Dicellograptus Smithi Pseudoclimacograptus cf. Scharenbergi Orthograptus sp. (O. Calcaratus type?) fragments of dichograptids Age: Zone of C. bicornis, zone 12 (zone 10 of Elles and Wood)

Locality shown in map	Description of collection
F4	USGS Clln. D2482CO (Field No. 1-153-4J) Palmetto Formation. Long 118° 08'50" W; lat 38° 04'20" N. Miller Mountain 7½' quad., Nevada Graptolites: Climacograptus Spiniferus Climacograptus Minimus? Dicranograptus cf. D. Rectus Hopkinson may be D. Nicholsoni Whitianus Orthograptus Truncatus Lapworth Retiograptus sp. Dicellograptus Morrisi? Cryptograptus Tricornis? Age: Zone 13b - upper subzone of O. Truncatus Intermedius zone. (Zone 11 of Elles and Wood)
F5	USGS Clln. D2483CO (Field No. 1-153-18J) Palmetto Formation. Long 118° 09'20" W.; lat 38° 04'20" N., Miller Mountain 7½' quad., Nevada. Graptolites: Dicellograptus Morrisi? Dicranograptus Spinifer Ruedemann Climacograptus Spiniferus Ruedemann Orthograptus cf. O. Truncatus Pertenuis (Ruedemann) O. Truncatus cf. var. Intermedius Age: Almost zertainly zone of O truncatus var. intermedius, zone 13b (zone 11 of Elles and Wood)

Locality shown in map	Description of collection
F6	USGS Clln. D2484CO (Field No. Js-73-25) Palmetto Formation. Long 118° 9'20" W.; lat 38° 4'40" N., Miller Mountain 7½' quad., Nevada. Cardiograptus Crawfordi Sinograptus Nodosus Amplexograptus or Diplograptus sp. Glossograptus sp. Cryptograptus sp. Age: Zone of P. etheridgei
F7	USGS Clln. D2485CO (Field No. Js-73-26) Palmetto Formation. Long 118° 9'20" W.; lat 38° 4'40" N., Miller Mountain 7½' quad., Nevada. Dicellograptus Gurleyi? Dicellograptus Sextans Hall D. Sextans var. Exilis E and W D. cf. D. Intortus Dicranograptus sp. Climacograptus Phyllophorus Gurley Orthograptus? sp. Age: Zone of N. Gracilis (zone 11), possibly also zone of C. bicornis (zone 12) (9-10 of Elles and Wood).
F8	USGS Clln. D2486CO (Field No. 1-162-10J) Palmetto Formation, Map unit 1 of Stewart; long 118° 8'20", W.; lat 38° 4'40" N. Dicellograptus or Dicranograptus sp. (fragments) Orthograptus cf. O. Truncatus type? Climacograptus cf. C. Caudatus Climacograptus sp. Neurograptid or Lasiograptid?

Locality shown in map	Description of collection
F8--continued	Age: Upper Ordovician, probably in span of zones 13-14 (zones 11-13 of Elles and Wood)
F9	USGS Clln. D2487CO (Field No. 1-153-9J) Palmetto Formation, Map unit 1 of Stewart, long 118° 8'50" W.; lat 38° 4'40" N. Dicellograptus or Dicranograptus sp. Orthograptus or Glyptograptus sp. Diplograptus? sp. Climacograptus? sp. Age: Upper Ordovician. Somewhere in zones 10-15 (zones 8-15 of Elles and Wood)
F10	USGS Clln. D2488CO (Field No. 1-153-32J) Palmetto Formation, Map unit 1, long 118° 9'20" W; lat 38° 4'50" N., Miller Mountain 7½' quad., Nevada Corynoides cf. C. Calicularis Dicranograptus cf. D. Rectus Hopkinson, very similar to D. Nicholsoni Whitianus Small biserial scandent species, not identified. Age: Best estimate somewhere in range of zones of C. bicornis (zone 12) to O. truncatus intermedius (zone 13) and probably the latter. (zones 10-11 of Elles and Wood).

Locality shown in map	Description of collection
F11	USGS Clln. D2489CO (Field No. 1-162-24J) Palmetto Formation, Map unit 4, long 118° 6'10" W.; lat 38° 4'20" N. Columbus 7½' quad., Nevada. From float at base of slope, not in place. Dicellograptus Alector Climacograptus Caudatus? Age: Zone of O. quadrimucronatus (zone 14) (zones 12-13 of Elles and Wood)
F12	USGS Clln. D2490CO (Field No. Js-73-29) Palmetto Formation, top of map unit 1. Long 118° 9'20" W.; lat 38° 4'40" N. Miller Mountain 7½' quad., Nevada. Glyptograptus sp. cf. G. Euglyphus Climacograptus? sp. Age: In span of zones 8-14 or 15 (zones 7-15 of Elles and Wood) and more likely in older part of that span as a guess.
F13	USGS Clln. D2491CO (Field No. 1-162-23J) Palmetto Formation, Map unit 4. Long 118° 6'10" W.; lat 38° 4'20" N. Columbus 7½' quad., Nevada. Climacograptus sp. (W equals 2.5; thecae 9/10 mm) Climacograptus sp. (L equals 12 plus mm, W equals 1.5 mm, thecae 12/10 mm, 1/3 ventral margin, 1/3 width) Climacograptus sp. (L equals 10 plus mm, W equals 1.8 mm, thecae 14/10 mm, 1/3 ventral margin, 1/4 width) Climacograptus sp. (L equals 12.5, W equals 1.8, thecae 10/10 mm, 1/2 ventral margin, 1/4 width)

Locality shown in map	Description of collection
F13--Continued	
	Orthograptus? sp. (L equals 25 plus mm, W equals 2.4, thecae 10/10 mm) Orthograptus sp. (This species is of Truncatus type)
	Age:
	Most likely in interval of zones 13-14 (zones 11-13 of Elles and Wood) - zones of O. truncatus intermedius to O. quadrimucronatus.
F14	USGS Clln. D2492CO (Field No. 1-16-74J) Palmetto Formation, long 118° 6'10" W.; lat 38° 5'0" N. Columbus 7½' quad., Nevada.
	Nemagraptid Cryptograptus Tricornis Carruthers Dicellograptus Sextans D. Sextans var. Exilis Climacograptus sp. Biserial scandent indet. Dicellograptus Intortus Dicellograptus GurleyI Glyptograptus? sp.
	Age:
	Probably zone of N. gracilis (zone 11) (zone 9 of Elles and Wood)
F15	USGS Coll. D2602CO (Field No. 1-117-8J) Palmetto Formation, C, sec. 5, T. 2 N., R. 34 E. Nevada Coord., west zone: E 39304 ft, N. 421209 ft. Approx. long 118° 13'0" W., lat 38° 3'30" N. Miller Mountain 7½' quad., Nevada.
	Graptolites:
	Didymograptus cf. D. Extensus Hall Didymograptus sp. (a more slender species)

Locality shown in map	Description of collection
F15--Continued	Sponges: Abundant molds of spicules Age: Arenig, zones 4-6 of Berry, zones 4-5 of Elles and Wood. More likely to be high Arenig than low.
F16	JS-74-3 (USGS Loc. 9619-SD): Long 118° 06'50"W.; lat 38° 04'10" N. Columbus 7½' quad., Nevada. The following conodont elements were identified: 2 I (icriodontan) elements (posterior part of platform missing) of *Icriodus* sp. 1 p element of *Polygnathus* sp. The elements are very poorly preserved, but there is no doubt as to their generic assignment. *Icriodus* ranges from very uppermost Silurian through Devonian. *Polygnathus* (of the type in this collection) ranges from upper Lower Devonian through Upper Devonian. Range of sample: upper Lower Devonian-Upper Devonian. The color alteration index is 6-7, indicating the host rock reached at least 400°C. JS-74-4 (USGS Loc. 9620-SD): Long 118° 06'50" W.; lat 38° 04'10" N. (same loc. as JS-74-3). Columbus 7½' quad., Nevada. The following conodont elements were identified: 1 A (hindeodellan) element 1 S (acodontan) element 1 p element of *Polygnathus* sp. 1 p element of *Ozarkodina* sp. These are the most poorly preserved conodonts in any of the samples, but again, the generic assignment is secure. Age range: upper Lower Devonian-Upper Devonian.

Locality shown in map	Description of collection
F16--Continued	The conodonts are crystal clear and have an alteration index of 8 indicating the host rock reached about 450°-500°C at least.
F17	Field No. JS-74-5 (USGS loc. 9617-SD): Long 118° 6'30" W.; lat 38° 04'40" N. Columbus 7½' quad., Nevada. The following conodont elements were identified: 13 I (icriodontan) elements (fragments and nearly complete elements of a long thin (at least 7 transverse rows of nodes) and no obvious lateral processes) of *Icriodus* sp. 22 S2 (acodontan and rotundacodontan) elements of *Icriodus* sp. 2 *Panderodus* sp. elements 2 p (spathognathodid) elements of *Ozarkodina* sp. or *Pandorinellina* sp. 3 N (neoprioniodontan and synprioniodinian) elements 1 A2 (plectospathodontan) element 1 A3 (diplododellan) element 7 simple cone elements, gen. indet. 11 bar and blade fragments 1 p element of *Polygnathus* sp. The acodontan, rotundacodontan, and icriodontan elements of *Icriodus* sp. indicate a Devonian age for this collection. The icriodontan elements are not complete enough for a closer age determination, but there is absolutely no doubt that these are Devonian conodonts. The plectospathodontan element also indicates a post-Ordovician age. The *Polygnathus* element indicates a late Early Devonian-Late Devonian age.

Locality shown in map	Description of collection
F18	Field no. JS-74-7 (USGS loc. 9618-SD): Same locality as USGS loc. 9617-SD, but different bed. Long 118° 6'30" W.; lat 38° 04'50" W. Columbus 7½' quad., Nevada. The following conodonts were identified: 3 simple cone elements, gen. indet. 12 bar and blade fragments 9 I (icriodontan) elements (all incomplete) of Icriodus sp. 2 p element fragments (posterior part) of Polygnathus sp. The Polygnathus sp. elements indicate a late Early Devonian-Late Devonian age. The conodonts have an alteration index of 5½-6, indicating the host rock reached +300°C.
F19	USGS Coll. D2789CO (Field No. 1-162-88J). Palmetto Formation, 2100 ft W. of hill 6050, long 118° 6'10" W.; lat 38°4'30" N. Columbus 7½' quad., Nevada. Dicellograptus cf. D. Complanatus Ornatus Elles and Wood ?Glyptograptus Altus Ross and Berry A small species of Glyptograptus or Orthograptus. Numerous stipes, probably of Dicellograptus, but all chloritized(?). Age: Zone 15 of Berry, zone of D. Complanatus Ornatus, Ashgillian.

Precambrian and Cambrian strata

Precambrian and Cambrian strata on Miller Mountain were originally studied by Ferguson and Muller (1949, p. 45) and, subsequently, named the Miller Mountain Formation (Ferguson and others, 1954). Wilson (1961) studied the area in detail and recognized five mappable units within the Miller Mountain Formation. In the light of Wilson's studies, Albers and Stewart (1972, p. 22) proposed that the name Miller Mountain Formation be abandoned; a proposal followed here.

Wilson (1961) correlated his five map units, from bottom to top, with, respectively, the Deep Spring, Campito, Poleta, Mule Spring, and Monola Formations of the White-Inyo Mountains area. These same general correlations were also described by Nelson (1963) and Albers and Stewart (1972), although Nelson (1963) and Albers and Stewart (1972) tentatively correlated the topmost unit with the "Cadiz" Formation and Emigrant Formation, respectively, rather than the partly equivalent Monola Formation. Wilson (1961) noted lithologic differences in some of these formations between Miller Mountain and the White-Inyo Mountains area and considered some of the correlations tentative. He also indicated that a major fault separated rocks correlative with the Poleta Formation from those correlative with the Mule Spring. This fault, in his view, accounted for the absence of the Harkless and Saline Valley Formations that in the White-Inyo Mountains lie between the Poleta and Mule Spring Formations.

Assignments of units made here differs from that of Wilson (1961). These changes are made on the basis of new mapping shown here and new stratigraphic and paleotological studies by C. A. Nelson (written commun., 1975) and by Moore (1976). Descriptions of these revisions follow.

The rocks mapped as Deep Spring Formation (Wilson, 1961) occur in secs. 13 and 24, T. 2 N., R. 34 E., and in areas extending about 1.5 miles east of these sections. They consist of calc-silicate hornfels, siliceous hornfels, and marble. Part of this sequence was assigned to the Harkless Formation by Albers and Stewart (1972). Neither the Deep Spring or Harkless assignments are accepted here. As shown on the map, these strata are in places assigned to the Campito Formation and in other places to the calc-silicate and siliceous hornfels unit of the Poleta Formation. These assignments are based on correlations with the stratigraphic sequence exposed on the main part of Miller Mountain (in secs. 15 and 22, for example).

Moore (1976) has indicated that the unit that Wilson (1961) correlated with the Mule Spring Limestone is in reality the upper member of the Poleta Formation. This revision is accepted here. The unit consists primarily of marble, but unlike the Mule Spring, it contains archeocyathids and oolitic and pisolitic layers (Moore, 1976). Ooliths and pisoliths are not found in undoubted Mule Spring, according to Moore (1976), and archeocyathids are not known from the Mule Spring. The highest known stratigraphic occurrence of archeocyathids in well-established sections in the White-Inyo Mountains is in the lower part of the Harkless Formation (Gangloff, 1976) about 300 m below the Mule Spring. For these reasons, Moore (1976) does not correlate the marble unit on Miller Mountain with the Mule Spring but considers it to be correlative with the lithologically similar, although generally thinner, upper member of the Poleta Formation. This correlation eliminated the need for a fault between the marble and underlying units, a fault that is not evident on the basis of field mapping.

The Poleta Formation as mapped here does not correspond exactly with the Poleta Formation described on Moore (1976) and C. A. Nelson (written commun., 1975) on Miller Mountain. These geologists, based on paleontologic and stratigraphic data, suggest that about the basal 60 m of the Poleta as mapped here (units A1, A2, and A3 of Wilson, 1961) are equivalent to the Campito Formation. The contact suggested by Moore and Nelson, however, does not appear to be a practical contact to map, and is not used here, although this practice does not dispute the correlations with the Campito that these geologist suggest.

The unit of siliceous hornfels overlying the marble unit (the upper part of the Poleta Formation described above) is considered to be the Harkless Formation by C. A. Nelson (written commun., 1975). This revision is accepted here. The siliceous hornfels unit was considered by Wilson (1961) to be correlative with the Monola Formation, a unit stratigraphically higher than the Harkless. The revised correlation is based on the similar stratigraphic position of the siliceous hornfels unit and the Harkless Formation, and on the lithologic similarity, except for greater metamorphism on Miller Mountain, of the siliceous hornfels unit and the Harkless. The original assignment of rocks on Miller Mountain to the Monola was based in part on paleontological data (Nelson, 1963); the *Ogygopsis*-bearing units on Miller Mountain were considered the same as the *Ogygopsis*-bearing units in the Monola Formation in the White-Inyo Mountains. Present evidence, however, indicates that *Ogygopsis* has a greater range than previously believed and extends to the base of the Harkless Formation (Nelson, 1976).

Devonian and Ordovician rocks, Miller Mountain area

A 1,500-m tectonic thickness of Devonian and Ordovician graptolitic shale, radiolarian chert, limestone, and calc-silicate hornfels occurs in the Miller Mountain and Columbus quadrangles. Lithologic, stratigraphic, and paleontologic characteristics of these rocks are described by Stanley, Chamberlain, and Stewart (1977) and Chamberlain (1977). East and northeast of Miller Mountain, the sequence is a well-exposed homoclinal succession in which individual units can be mapped for several kilometers.

Elsewhere, in the Miller Mountain and Columbus quadrangle, these units apparently cannot be recognized. East and northeast of Miller Mountain, Devonian conodonts have been recovered from units labeled Dl_2 and Dl_3; units Dl_1 and Dl_4 are also considered to be Devonian, because they contain some rocks lithologically similar to those in Dl_2 and Dl_3. Units Op, Op_1 and Op_2 contain Ordovician graptolites at various localities. The fossil data combined with field mapping indicate that the Devonian and Ordovician rocks are structurally interleaved, although the tectonic discontinuities have not been identified or mapped in the field. In an earlier synthesis (Stanley and others, 1977), thrust faults are shown separating the rocks classed as Devonian from those classed as Ordovician, although the position of these thrust faults could not be verified in the field. Because of the uncertain structural interpretations, no thrust faults are shown on the map presented here, although clearly some type of structural interleaving is required to explain the distribution of units. The interleaving of the rocks may well be due to thrust faulting in a style similar to that shown by Stanley and others (1977), but the position of the thrust faults could be considerably different, and more complicated, than that shown by them. The problem is complicated by the fact that the ages of the various units is not entirely known, and part of some units here classed as Devonian could be Ordovician, or visa versa. Conceivable rocks of other ages could also be tectonically interleaved with the Devonian and Ordovician rocks.

In the Devonian sequence, upright and overturned strata are distinguished on the basis of cross-stratified and graded units. In these units, sedimentary top is to the north to northeast. Indicators of upright or overturned rocks were not detected in the Ordovician strata; these Ordovician strata could contain major undetected overturned sequences.

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