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Road Guide through Lower Paleozoic Rock Units in the Osgood Mountains and Surrounding Areas, and a Stop at the Golconda Thrust Fault, Humboldt County, North-Central Nevada

by

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INTRODUCTION

The area of the Osgood Mountains, Edna Mountain, Hot Springs Range, and Sonoma Range in Humboldt County, Nevada (Figure 1) has prominent geologic and economic significance. The area embraces the type localities of several geologic units, the Golconda thrust fault on Golconda Summit (Edna Mountain), and the Getchell gold belt on east side of the Osgood Mountains. During 1989, there were five active gold mines along the Getchell gold belt: (1) Getchell, (2) Pinson, (3) Preble, (4) Rabbit Creek, and (5) Chimney Creek. At least some of the gold ore in all of the mines occurs in lower Paleozoic sedimentary rock units.

Lower Paleozoic rocks in the area consist of the following units, from oldest to youngest:

(1) Osgood Mountain Quartzite (Lower Cambrian and possibly Proterozoic; regionally metamorphosed sandstone, consisting of quartz arenite and sublitharenite, and shale (phyllite)); type locality in the southern part of the Osgood Mountains (Ferguson and others, 1951);

(2) Preble Formation (upper Lower Cambrian to Lower Ordovician; regionally metamorphosed shale (phyllite) with minor limestone, sandstone (sublitharenite and minor quartz arenite), and barite ; type locality at Preble ranch in Emigrant Canyon (Ferguson and others, 1951; Madden-McGuire and Carter, 1988; Madden-McGuire, 1988);

(3) Harmony Formation (Upper Cambrian; feldspathic sandstone, shale, and minor limestone); type locality in Harmony (Kluncy) Canyon, northern Sonoma Range (Ferguson and others, 1952);

(4) Comus Formation (Upper Cambrian and Lower Ordovician, dolomite, limestone, and shale, regionally metamorphosed to varying degrees); type locality on the northeastern flank of Edna Mountain (Ferguson and others, 1952; Hotz and Willden, 1964; Turner and others, 1989);

(5) Valmy Formation (Lower, Middle, and Upper Ordovician, sandstone, chert, and greenstone); type locality on North Peak, Antler Peak quadrangle (Roberts, 1949; Roberts and others, 1958; Roberts, 1964), which is about 26 mi (42 km) to the south-southeast; and

(6) Vinini Formation (Lower, Middle, and Upper Ordovician, chert, vanadiferous black shale, and sandstone); type locality in Vinini Creek, Roberts Mountains (Merriam and Anderson, 1942; Roberts and others, 1958; Finney and others, 1989), which is about 100 mi (161 km) to the southeast.

The contact relationships between various lower Paleozoic units are described briefly below. The Preble Formation overlies the Osgood Mountain Quartzite in a gradational depositional contact (Hotz and Willden, 1964). The Comus Formation overlies the Preble Formation in a depositional contact (Ferguson and others, 1952; Berger and Taylor, 1980; Kretschmer, 1984) that is a fault in most outcrops (Hotz and Willden, 1964). The Vinini Formation is in tectonic (Erickson and Marsh, 1974a) and possibly depositional (Madrid, 1987) contact with the Comus Formation. Hotz and Willden (1964) mapped volcanic rocks east of the Getchell mine as Valmy Formation, whereas Berger (1975) and Berger and Taylor (1980) reassigned them to the autochthonous Comus Formation. Parratt and others (1988) reported more Ordovician volcanic rocks to the northeast in the subsurface where shale, limestone, and basaltic lava flows and sills are overlain by a sequence with basaltic volcaniclastic rocks and more basaltic lava flows hosting the Rabbit Creek gold deposit. These rocks are similar to rocks that have been interpreted as autochthonous Comus Formation, rather than part of an allochthon (Berger and Taylor, 1980).

The arkosic sandstone of the Harmony Formation in the Sonoma and Hot Springs Ranges and Osgood Mountains is enigmatic because its contacts are mapped as faults and the sandstone is lithologically different from other Upper Cambrian strata (upper part of the Preble and lower part of the Comus). The Harmony Formation may not have been deposited near or at the same time as the Preble and Comus Formations. The age designation of the Harmony Formation is uncertain. Various studies, listed in chronological sequence, have suggested that it is Mississippian(?) (Ferguson and others, 1951), Late Cambrian (Hotz and Willden, 1964), Mississippian (McCollum and others, 1985), Silurian (McCollum and McCollum, 1987), and Late Cambrian (Madrid, 1987; Turner and others, 1989).

The nature of the lower Paleozoic sequence of strata suggests gradual water-deepening from at least Early Cambrian to Middle or Late Ordovician; it also indicates volcanism during the Ordovician. The depositional environments of the various units have been discussed in previous reports. The protolith for the Osgood Mountain Quartzite was sandstone (quartz arenite and sublitharenite) and shale (Hotz and Willden, 1964; Madden-McGuire, 1990) deposited on the continental shelf. These strata were overlain by shale (phyllite), limestone, and sandstone (sublitharenite and quartz arenite) of the Preble Formation (Hotz and Willden, 1964; Rees and Rowell, 1980; and Madden-McGuire, 1988 and 1990), which were deposited on the outer shelf and slope. The Preble Formation is overlain by slope and basin deposits of the Comus Formation (Ferguson and others, 1952; Berger and Taylor, 1980; Kretschmer, 1984) and possibly the Vinini Formation (Madrid, 1987). The Ordovician volcanic rocks may be alkalic, as are lower Paleozoic volcanic rocks of the Roberts Mountains allochthon (Turner and others, 1989), or tholeiitic ocean-basin basalt, though an alkalic composition is probable. The Upper Cambrian Harmony Formation has been interpreted as a proximal turbidite of a submarine fan (Rowell and others, 1979). This environment is consistent with the Late Cambrian paleogeography as it has been reconstructed from interpretation of the Preble and Comus Formations. However, the Harmony Formation still poses a paleogeographic problem because its arkosic detritus is absent from coeval slope deposits of the upper part of the Preble and lower part of the Comus Formation.

ROAD LOG

The following road log is to be used with published geologic maps of the various areas, which are available from the U.S. Geological Survey and Nevada Bureau of Mines and Geology (Hotz and Willden, 1964; Willden, 1964; Gilluly, 1967; Erickson and Marsh, 1974a, 1974b).

Winnemucca to Golconda to Midas Turnoff

1. Winnemucca Blvd. Downtown Freeway Entrance (Mile 178) to Golconda and Midas Freeway Exit (Mile 194) (Figure 6), 15 miles.

2. Turn left (north) and proceed 0.26 mile across the bridge over Interstate 80 to the stop sign at Golconda. This will be the zero mileage point for the following log to the Midas turnoff.

3. 0 miles Turn right (east) and proceed on paved County Road 18, which runs parallel to Interstate 80. Ahead on skyline is Edna Mountain. 2.21 miles from the stop sign at Golconda, the county road veers sharply to the left (north-northwest).

4. While travelling along the north-northeast stretch of the road, the abandoned Golconda Mine is visible to the right (east). The southern Osgood Mountains lie ahead to the north. On their left (southwest) side are golden hills of the Osgood Mountain Quartzite; on their right (southeast) side are lower lying gray hills of the Preble Formation, which is mostly covered by wind-blown sand. Note the easterly dip of strata.

5. 4.26 miles County Road proceeds around a curve to the northeast. Note the dirt road to right (east). This road crosses the northern part of Edna Mountain and, along the way, it provides access to several barite mines in the Preble Formation. Proceed through Emigrant Canyon here, crossing the Humboldt River at 5.90 miles.

6. 6.21 miles Railroad crossing and ranch at a site called Preble.

7. 7.25 miles Road leading to the Preble gold mine is on the left (west).

8. 13.08 miles Road (marked "Private Road") to left (northwest) trends east-west and provides access to the old County Road 18, Lone Butte, and barite mine in the Osgood Mountain Quartzite. Road is used by Pinson Mining Company.

9. 13.61 miles Road to left (northwest) goes to the "Pettit Ranch" and to Soldiers Pass. The "Pettit Ranch" was labeled "Hugh Bains Ranch" on the 1945 Osgood Mountains 15' topographic map.

10. 15.8 miles Intersection of five roads here, including paved County Road 18, the road to the gold mines (Pinson, Getchell, Rabbit Creek, and Chimney Creek), the road to Midas, and the road to Hogshead Canyon and Redhouse barite mine

Osgood Mountain Quartzite, Soldiers Pass, Southern Osgood Mountains

1. At 13.61 miles from the stop sign in Golconda, and 2.24 miles from the five-road intersection (Midas turnoff), is the road to the "Pettit Ranch" and to Soldiers Pass. This turnoff will be the zero mileage point for this part of the road log (Figure 2).

2. Proceed only 0.87 mile to the northwest on this road, then turn left (west) BEFORE the ranch. Proceed 0.26 mile along fence, then turn right (west) at fence corner and follow the road along the AT&T Transcontinental Cable Route westward toward the mountains.

3. 3.98 miles Spring to the south of the road is called Dog Spring on the topographic map. Another spring is shown on the topographic map about a mile to the northeast, along the mountain front.

4. 4.54 miles Hilltop (closed contour). Quartz arenite of the Osgood Mountain Quartzite is exposed a short distance uphill to the north. The rocks in this outcrop are cut by veins of milky white quartz and are strongly fractured. Bedding is indistinct; it seems to strike northeast/southwest and dip to the east.

5. 5.13 miles Down in gully to the SE there are outcrops of sandstone of the Osgood Mountain Quartzite, including outcrops of sandstone of its Twin Canyon Member. There is a place to park on the south side of the road with space enough for about two vehicles, possibly more.

6. 5.54 miles Fence and unlocked gate at top of Soldiers Pass, at about 5,500 ft. elevation.

7. 7.03 miles Outcrops of quartz arenite of the Osgood Mountain Quartzite above and below road. Outcrops below road are excellent; they show cross-stratification and isoclinal folding of the sandstone. Strike of strata is northeast/southwest and dips range from steep westerly to vertical.

8. 7.9 miles Hilltop of Tertiary volcanic rocks. This is unit Tva, mapped and described by Hotz and Willden (1964) as chiefly andesitic and basaltic andesite flows.

9. 10.05 miles Intersection with the main gravel road that leads back to Golconda and Interstate 80. Turn south here.

10. 17.9-18.0 miles Cross two small bridges over the Humboldt River and cross the tracks of the Union Pacific railroad (the first of two sets of railroad tracks). 20.05 miles Turn right (south) at intersection and cross the tracks of the Southern Pacific railroad (second set of railroad tracks). 20.36 miles Stop sign at Golconda. Interstate 80 entrances are ahead (east) and to right (west).

Osgood Mountain Quartzite at Barite Mine

1. 13.08 miles from Golconda, and 2.77 miles from the Midas turnoff (five-road intersection), is an east-west trending road to the west that is marked "Private Road". This road provides access to the old county road that runs parallel to the newer paved road, to Lone Butte, and to a barite mine in the Osgood Mountain Quartzite. Turn west on this road. The turnoff is the zero mileage point for this part of the log (Figure 2).

2. 1.08 mile Turn southwest on old county road.

3. 4.34 mile Turn west on road to barite mine.

4. 6.46 miles Note outcrops of the Twin Canyon Member of the Osgood Mountain Quartzite to north, across the gully.

5. 7.08 miles Note outcrops of resistant sandstone of the Osgood Mountain Quartzite to north, across gully.

6. 7.74 miles Barite mine in sandstone and phyllite of the Osgood Mountain Quartzite.

7. 8.05 miles Uppermost mine area near hilltop, above switchbacks. At top of hill are good outcrops of sandstone (mostly quartz arenite) of the Osgood Mountain Quartzite, showing cross-stratification. Beds strike northeast and dip to the east. On the northern side of the hill, a short distance down from the top, is a zone of altered rocks, some of which show turquoise weathering products derived from copper minerals. The sandstone is reddish to maroon in these altered outcrops. This alteration may be stratigraphically controlled in part. At the northwestern end of this elongate, flat hilltop are more outcrops of the quartz arenite. Some of these rocks are fractured and isoclinally folded. The subtle fold noses are visible locally.

Preble Formation on South Side of Emigrant Canyon, near Preble
{Subunits Cpi, Cpo, Cpic, and Cps}

1. 4.26 miles northeastward along County Road 18 **from the stop sign in Golconda**, turn (right) east on a dirt road to view several Cambrian subunits of the Preble Formation (upper lower Cambrian to Lower Ordovician). This intersection is the zero mileage point for this part of the road log (Figure 3).

Discussion of the Preble Formation

The discovery and mining of disseminated and jasperoidal gold deposits in the Preble Formation and the adjacent Comus Formation (in the Getchell, Preble, and Pinson mines) increased interest in the stratigraphy and structure of the deformed host rocks. The Lower Cambrian to Lower Ordovician Preble Formation consists primarily of intensely deformed phyllitic shale and slate, interbedded limestone, and sandstone that have been regionally metamorphosed to greenschist facies. In this area, the rocks are tightly folded and overturned to the west. The type area of the Preble Formation surrounds the Preble ranch. The ranch is in Emigrant Canyon, along County Road 18. We will examine rocks in the type area southwest of the ranch.

Stratigraphic problems in the Preble Formation have included determining the direction of stratigraphic up, determining the number of limestone subunits, estimating the thickness of the unit (still uncertain), and interpreting the significance of bedded barite in the formation. In summary, field and fossil data indicate that the prevailing direction of stratigraphic up in this area appears to be to the east, except for the upside-down limbs of overturned folds. Present mapping suggests that there are at least six or seven limestone subunits, three of which are extensive (two are particularly thick and resistant) in this area. Distinctive limestone beds in the Preble in this area are (1) an extensive, thick, blue-gray oolitic limestone (subunit Cpo) that contains irregular patches of orange-brown weathering dolomite, calcite, and quartz, (2) thick lithoclastic limestone conglomerate (subunit Cplc), and (3) thinner pale-orange, fossiliferous limestone containing Early Cambrian trilobite (*Wanneria*) fragments (subunit Cpl). The significance of bedded barite in the Preble Formation is debatable. The barite may represent (1) relatively late (Cretaceous or Tertiary) hydrothermal replacement of limestone along noses of isoclinal folds, (2) late veins emplaced parallel to metamorphic cleavage, or (3) Paleozoic sedimentary exhalative deposits. We will examine several distinctive limestone (and sandstone) subunits and a mine exposure of bedded barite in the Preble Formation.

2. 0.42 mile Subunit Cpo, the oolite marker bed, is to the left (north) side of the road. The oolite is a blue-gray limestone with distinctive orange-brown lenses of dolomite and silica. Bedding thickness ranges from a few inches to over 3'. Beds are isoclinally folded, but the noses of folds are subtle and not obvious. Locally, the oolite contains a limestone pebble conglomerate that is especially visible in float blocks. A short distance to the east is an outcrop of subunit Cplc, limestone conglomerate, described below.

3. 0.45 mile Subunit Cplc, the limestone conglomerate, is exposed on the left (north) side of the road at the intersection. This is a blue-gray limestone and its beds range in thickness from 3-4" to over 1'. These beds are isoclinally folded, but fold noses are not obvious. Clasts are limestone. Most clasts are blue-gray limestone and hard to see; some clasts are weathering to brownish colors and are easier to see. All clasts are interpreted as fragments of slope and shelf deposits. Elsewhere, the conglomerate contains clasts of oolite.

   Correlative limestone strata nearby contain Middle Cambrian trilobites (such as *Kootenia*) and brachiopods (Rees and Rowell, 1980; Madden-McGuire, 1990)

4. 0.63 miles Subunit Cps. Siliciclastic turbidites(?) or marine-channel overbank deposits(?) are exposed on the left (north) side of the road. Here, subunit Cps is fairly evenly bedded, with bedding <1"-1' thick. Most beds are between one inch and five inches thick. Thicker beds show rare cross stratification. Bedding surfaces are micaceous, locally burrow mottled, and oxidized, suggesting quiescent periods of no deposition or only slow deposition of suspended sediment between intervals of more rapid sand deposition. The strata are isoclinally folded.

5. 0.64 mile Turn to the right and proceed up the hill past the South Horton barite mine on the right side of the road (to the west). At 0.81 mile stay on the road to the south rather than turning westward into the mine. Ahead, pass outcrops of subunit Cplc (limestone conglomerate) on the left (east).

6. 0.98 mile Subunit Cpo, oolite, is exposed in a map-scale fold nose on the hillside to the right (northwest). Fold closes to the north and is shown on the 1:24,000-scale geologic map of the Golconda quadrangle (Erickson and Marsh, 1974a).

7. 1.06 mile Subunit Cpo, oolite, is exposed on both sides of the road. At this point, the road is located along the axis of a map-scale, overturned fold, and is flanked by east and west limbs.

8. 1.15 mile Subunit Cplc, limestone conglomerate, is exposed a short distance from the road on the right (west) side. This outcrop contains a large 30" clast of oolite as well as smaller clasts of limestone. The conglomerate is overlain by thinner beds of limestone with bedding about 1" thick.

9. 1.44 miles T-shaped intersection with another dirt road that runs east-west, up and down the hill.

   Uphill to the east, about 0.1 mile are outcrops of subunits Cpo (in gully) and Cplc (up on hillside). The two subunits are very close together at this locality. Subunit Cpo, oolite, has an apparent (maximum) thickness of about 40' and subunit Cplc, limestone conglomerate, has an apparent (maximum) thickness of about 50' at this locality. (Folding in these subunits makes the apparent thicknesses be maximum thicknesses. Telescoping due to thrusting is not considered significant in this particular interpretation).

10. Turn right (west) at the T intersection and proceed to mile 1.56 of the log. Here, the road crosses subunit Cpl, the pale-orange limestone fossil hash, at an angle approximately normal to the strike of bedding. The subunit is only about 2' thick here; bedding thicknesses range from <6" to about 1'. Subunit Cpl can be followed northward along the hillside.

    Subunit Cpl contains an abundance of tiny, unimpressive fossil fragments, among these are fragments with a distinctive reticulate, or honey-comb, pattern. A.R. Palmer identified the distinctive scraps as the olenellid trilobite genus *Wanneria*, which in most collections is associated with one or more species referable to the trilobite genus *Bonnia*. This association is representative of the middle part of the *Bonnia-Olenellus* zone in North America (A.R. Palmer, written commun., 1989). Previous occurrences of *Wanneria* in the Great Basin have been in beds immediately on top of strata that are lithologically equivalent to the Zabriskie Quartzite in Esmeralda County and at Cucomungo Canyon, both in the outer shelf facies of Lower Cambrian strata (A.R. Palmer, written commun., 1989).

    Subunit Cpl is interpreted as an outer shelf deposit, transitional between the pure shelf sandstone (quartz arenite) of the Osgood Mountain Quartzite (Lower Cambrian and possibly Proterozoic) and the slope deposits of the middle part of the Preble Formation (upper Lower Cambrian and Lower Ordovician).

11. From the outcrop of subunit Cpl, one can return to County Road 18 by retracing the preceding route or by continuing to the west through the diggings associated with the Golconda manganese and tungsten mine. If you continue to the west, use the following road log, which progresses continuously from the preceding mileages. 1.64 miles At the hilltop, veer to the left on the newer drilling road, constructed in 1988.

Golconda tungsten and manganese mine.

The manganese and tungsten deposits of the Golconda mine were studied by various earlier workers. Among them was Kerr (1940), who described two forms of ore: (1) nearly flat-lying stratified "caps" (also called fan-shaped "blankets") beneath tufa (travertine) and above an erosional surface on bedrock (now called Preble Formation) and (2) vertical fissure fillings in the underlying bedrock. The tungsten deposits occur along a N 25° E trending faulted belt, but Kerr (1940) found no single, continuous, near-surface fault or "quartz lode" along the belt.
The ore occurs in both manganiferous and ferruginous material (separated into different layers and streaks) in the layered deposits and in the veins. The mineralogy of the ferruginous material includes quartz, sericite, calcite, dolomite, feldspar, and tungsten-bearing hydrated ferric oxide (tungsten-bearing limonite). The manganiferous material consists of tungsten-bearing psilomelane, hollandite, and possibly pyrolusite (Kerr, 1940). Marsh and Erickson (1975) found enrichments in other metals in addition to tungsten (arsenic, cobalt, germanium, thallium, and beryllium) and a partitioning of the enriched metals such that tungsten, cobalt, and strontium occur in the manganiferous material and most of the arsenic occurs in the ferruginous material. They said that the mineralogy of the various trace metals is complex and virtually unknown.
Questions still exist regarding the mineralogy of the tungsten ore in both the ferruginous and manganiferous layers of the Golconda deposit (Marsh and Erickson, 1975). In particular, the tungsten-bearing mineral in the ferruginous layers is only known as a tungsten-bearing limonite and the manganese mineral is a tungsten-bearing psilomelane mixed with what may be very fine, anisotropic hollandite (Kerr, 1940). Kerr (1940) interpreted the ore as limonite containing adsorbed hydrated tungstic oxide, tungsten-bearing psilomelane, and tungsten-bearing

hollandite.

Kerr (1940) found that a 65" section of layered ore and altered bedrock in a mine trench had an average value of 2.75% WO_3 , and the manganiferous ore contained about 66% MnO. The layered ore contains greater W enrichment than the veins. Samples from a 15' area through veins yielded only 0.33% WO_3 (Kerr, 1940).

Kerr (1940) pointed out that the calcareous tufa and the underlying, bedded manganiferous and ferruginous tungsten-ore horizons were genetically associated deposits of hot springs and that the tufa was not a precipitate from supersaturated waters of Lake Lahontan, as was previously believed, because the ore occurs at least 100' above the high-water level of the lake. He suggested that the stratified ore underlay and preceded formation of the older of two generations of tufa and that the lower vein deposits enriched in tungsten represented the final stage in hydrothermal activity. White (1955) suggested that although manganese veinlets cut travertine locally, it is likely that the travertine and tungsten-enriched deposits formed contemporaneously, the travertine at the surface and the tungsten-bearing material at depth. White (1955) suggested that the travertine was deposited from water emerging from a fissure in limestone up the pediment surface from the deposits.

12. <u>1.88 miles to 1.95 miles</u> Uphill, to the east, are outcrops of a heavily veined (milky white quartz veins) and fractured silicic rock that closely resembles quartz arenite of the Osgood Mountain Quartzite, as seen in the southern Osgood Mountains near the barite mine and along Soldiers Pass.

13. <u>2.05 miles</u> Turn right (north) at the intersection to return to County Road 18. <u>2.33 miles</u> Veer to the left and take the southernmost of the three roads, which leads westward to the paved county road. <u>2.75 miles</u> Intersection with County Road 18.

Preble Formation on South Side of Emigrant Canyon, near Preble
{Subunits, Little Britches barite mine, and graptolites}

1. Turn eastward off from County Road 18 onto the dirt road that is about 4.26 miles northeast from the stop sign in Golconda. This will be the zero mileage point for this part of the road log (Figure 3).

2. <u>0.64 mile</u> Proceed eastward past the intersection where roads lead to the northern and southern Horton barite mines.

3. <u>0.76 mile</u> Pass the open white metal gates and note the folded limestone beds (Cplc) to left (on north side of road). These folds are interpreted as minor, cognate structures on the limbs of major, map-scale folds, that originated by layer-parallel shortening before the onset of buckling. These folds were further deformed during orogenic flexural-slip folding of the strata. Farther east, the reddish hillside exposes the oolite.

4. <u>0.86 mile</u> Subunit Cplc is exposed on both sides of the road. The low-lying exposure to the south includes beds of limestone conglomerate. Farther to the east on the reddish hillside there are exposures of the oolite.

5. <u>1.43 mile</u> Turn to the left (north) and follow the road up the hill past the southern pit to the northern pit of the Little Britches barite mine. <u>1.58 miles</u> Turn left (westward) into the are of the north pit.

   Bedded barite is folded with thin-bedded limestone and phyllite of the Preble Formation in this mine. The best place from which to view a synform is the western edge above the pit, where one can look downward at the east wall. The barite was mined around the nose of the synformal fold that is so well exposed. The west wall exposes what may be a very tight antiform. Folding of the bedded barite, which is concordant to adjacent strata, suggests that either the bedded barite is Paleozoic in age (since folding occurred before deposition of the Lower Pennsylvanian Battle Formation; see Erickson and Marsh, 1974a) and the product of exhalative deposition, or that barite replaced limestone.

Note the black, burrow-mottled?, pyrite-bearing shale and barite rosettes in the gossan zone that seems to be folded around the barite on the north wall. The gossan consists of goethite, jarosite, barite, and calcite, according to X-ray diffraction analyses (T. Botinelly, written commun., 1988). The overlying, thin-bedded limestone locally contains flat-pebble conglomerate with imbricated, elongate clasts.

Rees and Rowell (1980) reported a collection of probable Middle Cambrian fossils from limestone immediately north of the pit. The limestone unit in the barite mine may be correlative with subunit Cplc, the limestone conglomerate, but there is no sign here of the adjacent oolite (Cpo).

6. To view the phyllite at the graptolite locality, proceed northward up the hill along the road that runs on the east side of the pit, to mile 1.73.

7. 1.73 miles Turn right (eastward) and proceed downhill along the ridgetop road. At mile 2.4 there is a very steep, short hill.

8. 2.5 miles Orange-weathering, silicified limestone is exposed in the gully to left (northwest). Its age and correlation with subunits is unknown.

9. 2.71 miles The hilltop to the southeast exposes graptolite-bearing light-gray phyllite mapped as the Preble Formation (Erickson and Marsh, 1974a). There is parking room along the gully to the southeast at 2.66 miles. The graptolites are sparse and poorly preserved. Metamorphism has obscured the outlines of thecae, so identifications were based only on gross incomplete rhabdosome shapes (branching patterns). The branching patterns displayed by some of these samples are strictly limited to the Early Ordovician (Tremadocian and (or) Arenigian) (Claire Carter, written commun., 1988).

10. 3.48 miles Turn left at the intersection to return to County Road 18.

11. 4.71 miles Intersection with county road. Turn left, southwest, to return to Golconda and Interstate 80.

Paleozoic tectonics in the Edna Mountain area:

Erickson and Marsh (1974a,c) noted the overturned-to-the-west folds in the Osgood Mountain Quartzite and in the Preble Formation in the southern Osgood Mountains and Edna Mountain area. They said that the overturned structure in these units does not conveniently relate to either the Antler or the Sonoma orogenies and suggested that there was Cambrian to Ordovician deformation preceding the Antler orogeny (Erickson and Marsh, 1974c, Fig. 2). They also found a pre-Sonoma (Late Pennsylvanian or Early Permian) thrust fault in the Golconda area, which they called the Iron Point thrust (Erickson and Marsh, 1974c, Fig. 3).

Comus and Vinini Formations, South of Iron Point

1. Take I-80 to the Iron Point exit at mile 203 and drive north to the cattle guard beneath the power lines. This will be the zero mileage point for this part of the log (Figure 4). Proceed across the small gully and to the north, ignoring the roads leading to the right (eastward) at 0.4, 0.66, and 0.89 miles.

2. <u>0.94 mile</u> Turn to the right and drive up the hill. <u>1.26 miles</u> Again, proceed to right on main road up the hill.

3. <u>1.3 miles</u> Turn right and proceed down the gully to the northeast. <u>1.66 miles</u> Track curves to the left (north) and runs along the side of the ridge.

4. <u>2.09 miles</u> The road to the left goes westward through a canyon that exposes the Comus Formation. The north-south road (really just a track) proceeds another 0.28 mile to the north to the Silver King Mine and a graptolite locality in the lower member of the Comus Formation. If one proceeds to the north, at <u>2.37 miles</u> there are mine tailings up the hill to the left. A graptolite locality occurs ahead to the north in the gully, and uphill a short distance, in the light-gray to olive-gray, very fine grained siltstone. Erickson and Marsh (1974b) referred to this fine-grained rock as "desert scenic stone" or "Nevada wonder stone" because of the colorful pale-reddish brown, concentric rings of ferric iron oxide on bedding and fracture surfaces. The rock contains an excellent Middle Ordovician graptolite fauna.
Up the hillside on the north side of the gully are good exposures of the thinly interbedded black chert and gray dolomite of the lower member of the Comus Formation; bedding is generally less than 6" thick. Limited X-ray analyses suggest that the dolomite consists of 80-90% dolomite, about 5% calcite, and about 5-10% silica; the chert consists of silica and about 5% clay minerals (illite) (T. Botinelly, written commun., 1989).

5. <u>2.09 miles</u> Back at the last intersection, turn left (west) into the canyon. Note the silicified breccia at the entrance of the canyon. The silicified rock has been interpreted as a fault breccia that occurs along a north-south trending fault here, that is down-dropped to the east into the basin. Erickson and Marsh (1974b) considered this to be the lowermost unit of the lower member of the Comus Formation, and suggested that it might have been a dark quartzite before the intense brecciation destroyed its original identity. Outcrops of silicified rocks occur in the canyon for about 0.2 mile. This is the lower member of the Comus Formation, which consists of chert, dolomite, and possibly quartzite (Erickson and Marsh, 1974b). Note the thin bedding and dark-gray, fine-grained, carbonaceous look of the dolomite.

6. <u>2.31 mile</u> Contact between lower and upper members of the Comus Formation. The upper member is dolomitic siltstone and silty dolomite (Erickson and Marsh, 1974b). The exposures of pale to moderate reddish brown siltstone on the north side of the road range from burrow mottled to intensely bioturbated by bottom dwelling marine organisms, possibly in an oxidizing environment with periods of very slow deposition to no deposition. The intense churning of the sediment may have destroyed body fossil remains. No fossils were found in this part of the Comus Formation (Erickson and Marsh, 1974b).

7. <u>2.94 miles</u> Ridgetop locally covered with chert float of the Vinini Formation.

8. <u>3.51 miles</u> Intersection with original road. To view the Vinini Formation, turn to the left (east) and proceed less than 0.1 mile to the intersection with a road that leads uphill to the south.

9. <u>3.59 (1.3 mi from zero) mile</u> Turn right and proceed uphill to outcrops of the Vinini Formation.

10. <u>3.63 (1.59 mi from zero) mile</u> Folded, contorted chert of the Vinini Formation is exposed along the roadcut; limbs of folds dip to the west. Erickson and Marsh (1974b) observed that isoclinal and recumbent drag folds in the Vinini Formation indicate movement from west to east and they mapped these strata as part of a thrust sheet that may represent the Roberts Mountains allochthon of the Late Devonian to Early Mississippian Antler orogeny.

Comus Formation, Hogshead and Felix Canyons, Osgood Mountains

1. At the Midas turnoff (intersection of five roads that is 15.8 miles northeast of the stop sign in Golconda) turn left (northwest) toward the mountains (Figure 5).

2. 1.99 miles Road to left (south) is the turn off to the Redhouse barite mine. The mine is a good collecting locality for complete, spherical barite-rosette specimens. The barite is bedded and it occurs in Ordovician rocks that were mapped as the Comus Formation by Hotz and Willden (1964), but are referred to informally as the Vinini Formation by R. Madrid (written commun., 1989). The bedded barite may be "sedex" deposits of submarine exhalative activity during Middle or Late Ordovician time. Graptolites collected from about 15 ft below the barite horizon are similar to forms from the upper part of the Middle to lower part of the Upper Ordovician (E. Kretschmer, Pinson Mining Co., written comm., 1989).

3. 2.46 miles Outcrops of dolomite of the Comus Formation are on the hillside on the right (north). These are partly silicified dolomites (approximately 15% each of silica and calcite and 70% dolomite, based on X-ray analysis of one sample) that do not react strongly with acid. Note the sedimentary conglomerates containing angular clasts of dark gray dolomite and chert (probably diagenetic silicification of limestone).

4. 2.91 miles The turnoff to the left (northwest) goes to uppermost Hogshead Canyon, which exposes limestone and sandstone of the Preble Formation. Exposures are easily accessible on the road and below the road on the south side of the ridge.

5. 4.11 miles At about this mileage, make several right turns so as to go southeastward down Felix Canyon. There are outcrops of limestone of the Comus Formation at 4.56 miles (on the south side of the road down the hillside) and at about 5.16 miles (north of the road on a hillside across the gully). The first outcrop exposes thinner bedded limestone and silicified limestone, with beds about 2-5" thick. The second outcrop is more extensive and exposes the thinner bedded limestone as well as sedimentary limestone breccia with clasts of dark-gray limestone and chert (silicified limestone?) in a matrix of lighter gray limestone.

6. 6.03 miles Intersection with the mine road that leads south to the County Road. Turn right (south) to return to Golconda.

7. 8.33 miles Turnoff to Midas at the five-road intersection. Golconda is 15.8 miles to the southwest.

Valmy Formation, East Side of Hot Springs Range

1. Rocks mapped as the Valmy Formation by Hotz and Willden (1964) are exposed on the southeast side of the Hot Springs Range, on a butte that is close to the main gravel road. These outcrops, which can be reached from the west side of Soldiers Pass or from Golconda, expose a highly fractured, very pure quartz arenite that resembles the Osgood Mountain Quartzite. The sandstone lacks the conspicuous bedding and cross stratification that characterize many outcrops of the Osgood Mountain Quartzite. The rocks on the butte were mapped as the Valmy Formation because of the abundant black chert(?) (silicification of another rock type?) and associated altered volcanic rocks (Hotz and Willden, 1964). No fossils were found on which to base an Ordovician age for the unit. Gray phyllitic shale is exposed in natural and mined-out outcrops. This phyllite has been examined briefly during recent field study, but no graptolites have been found.

2. From the Stop Sign in Golconda (zero mileage point) (Figures 2 and 6), proceed to the north. Cross railroad tracks of the Southern Pacific railroad at 0.49 mile and turn left (west) on the other side. Road veers to right (north) at about 0.9 mile. The Golconda hot springs are to the

north here. The anomalous radioactive water, at 109-165° Fahrenheit, is depositing travertine. Enriched metals include As (0.02 ppm), Mn (0.10 ppm), Cu (0.05 ppm), Hg (0.0001 ppm), and Li (0.36 ppm) (Garside and Schilling, 1979). At 1.77 miles cross the tracks of the Union Pacific railroad (the second set of railroad tracks). At 2.49 miles, slow for a narrow bridge with deeply rutted, corrugated road that forms on either side. Proceed north and northwest on the main gravel road toward Eden Valley.

3. Turn left (northwest) at 10.9 miles. Proceed about 0.15 mile to an intersection and turn left (west), then proceed another 0.3 mile to the base of the butte exposing the quartzite. There is a mine a short distance to the north, along the hillside. It is not certain what was being mined here, but the exposed quartzite on the wall of the prospect is stained red and yellow on fracture surfaces, and fresh surfaces show tiny veinlets of dark-gray material.

   Hotz and Willden (1964) reported quartzite, chert, siliceous shale, and some interbedded altered volcanic rocks in the Valmy Formation on the east side of the Hot Springs Range. Some of the chert may be silicified shale and some contains shardlike outlines and clots of chlorite and may be silicified volcanic tuff (Hotz and Willden, 1964).
   They reported very altered volcanic rocks in the outcrops on this butte. They described dense, green and gray, very sheared rocks that consist of chlorite, with minor magnetite and calcite. East of the Getchell mine, on the east side of the Osgood Mountains, Hotz and Willden (1964, p. 22) mapped what they called "dark greenish-gray fragmental altered volcanic rocks" as the Valmy Formation. Berger (1975) and Berger and Taylor (1980) later grouped these volcanic rocks into the Comus Formation in discussions about the mineralization and movement along the Getchell fault.

4. To reach the butte from the west side of Soldiers Pass, turn right (northwest) on the main gravel road. At about 0.59 mile, turn left (northwest) and proceed another 0.15 mile to an intersection. Turn left and proceed westward about 0.3 mile to the base of the butte.

Valmy and Harmony Formations, Southeastern Hot Springs Range

1. **Valmy Formation and Valmy-Harmony Formation contact:** From the stop sign in Golconda, drive northward toward Eden Valley. At 16.77 miles, turn west on a dirt track towards the Hot Springs Range. **This is the zero mileage point for this part of the road log** (Figure 6).

2. 1.43 miles Exposures to north (right) on the hillside are sandstone (quartzite) of the Valmy Formation. The road becomes hard to follow, having become numerous cow paths.

3. 2.48 miles The saddle at the highest point on this 'road' exposes the contact between the Harmony and the Valmy Formations, which is mapped as a fault (Hotz and Willden, 1964). At this locality, sandstone of the Harmony Formation dips to the east, whereas sandstone of the Valmy Formation dips to the west, based on a few observations of limited outcrops.
   From here, one can retrace ones path back to the main gravel (the quicker way) road or go forward and follow cow paths down into the next canyon to the north and then go eastward to the main gravel road.

4. **Harmony Formation:** From the stop sign in Golconda, drive northward about 14.76 miles and turn westward towards the Hot Springs Range. This road continues about 4.51 miles to the top of the range and exposes sandstone and phyllite of the Harmony Formation in various spots.
   There is uncertainty concerning the age of deposition of the Harmony Formation. Hotz and Willden (1964) and Rowell and others (1979) considered the formation to be Late Cambrian in age based on identifications of trilobites from limestone in the Hot Springs Range and Osgood Mountains. However, McCollum and others (1987) found evidence at Battle Mountain that the Harmony might be as young as Silurian. The evidence for a Silurian age of deposition consists

of field observations that the formation depositionally overlies Middle and Upper Ordovician strata, which they assigned to the Ordovician Valmy Formation (assigned by previous workers to the Scott Canyon Formation). They indicated that the Cambrian trilobites previously found in the Harmony and in underlying strata were actually in limestone olistoliths within debris flows and, thus, did not represent the age of deposition of the enclosing strata. In contrast, work by Madrid (1987) and Turner and others (1989) suggested that the Harmony Formation is, indeed, Late Cambrian in age as had been indicated by Hotz and Willden (1964). The Late Cambrian age is based on trilobites from the Hot Springs Range (Hotz and Willden, 1964), inclusion of the Harmony Formation within the Late Devonian and Early Mississippian Roberts Mountains allochthon, and the presence of Harmony-like detritus in westerly derived Lower Ordovician sandstone of the allochthon (Madrid, 1987). An Upper Cambrian Harmony Formation is thought by some (1) to have formed far to the west of the strata constituting the allochthon, (2) to have become a topographically high, upfaulted, westerly source for Ordovician sand that was shed eastward into an extensional basin, and (3) to have been subsequently overthrust eastward to its present area of exposure during the Antler orogeny (Madrid, 1987).

Golconda and Iron Point Thrust Faults, Golconda Summit

1. From the Stop Sign in Golconda, turn right (east) and proceed to the east for 2.16 miles. Turn right (east) onto the old, abandoned highway to Golconda Summit (Figure 7).

2. 2.44 miles The hill to the north exposes the Osgood Mountain Quartzite, which is locally folded. Generally, bedding dips to the west.

3. 4.37 miles The Antler Peak Limestone (Upper Pennsylvanian and Lower Permian) is exposed on the hillside facing west and on the roadcut along old highway 40. The Antler Peak Limestone is part of the Antler overlap sequence, which overlies deformed rocks of the Antler orogeny. The Antler Peak Limestone has been mapped as part of the Iron Point allochthon here (Erickson and Marsh, 1974a), having overridden the Preble Formation on the Iron Point thrust fault. The outcrops on this hill generally lack evidence for a thrust-fault contact and suggest an unconformable sedimentary contact locally. On the west side of the hill, a drainage exposes the contact well and on the east side of the hill, much of the canyon exposes the contact. The Antler Peak Limestone does not appear folded in either exposure. However, these more accessible exposures near the freeway may be deceptive. Erickson and Marsh (1974c, Fig. 3) show a photograph of the Iron Point thrust fault in sec. 33, T. 36 N., R. 41 E., in the Iron Point quadrangle, where folded strata of the Antler overlap sequence have ridden over the Preble Formation as a plate.
   Above the roadcut, higher up on the hill, the Antler Peak Limestone is overlain by the Edna Mountain Formation (Upper Permian), which is a blocky weathering sandstone containing characteristic black chert fragments.

4. 4.66 miles Turn left (north) near the end of the old highway, then turn left again to go to a roadcut at 4.73 miles. This roadcut exposes the upper plate of the Golconda thrust fault. Note how the rocks are folded and contorted here. The upper plate exposes the Pumpernickel Formation (Pennsylvanian and Lower Permian) and which consists of chert, shale, and greenstone, as well as quartzite and minor limestone, all exposed to the east and northeast along the top of Edna Mountain.

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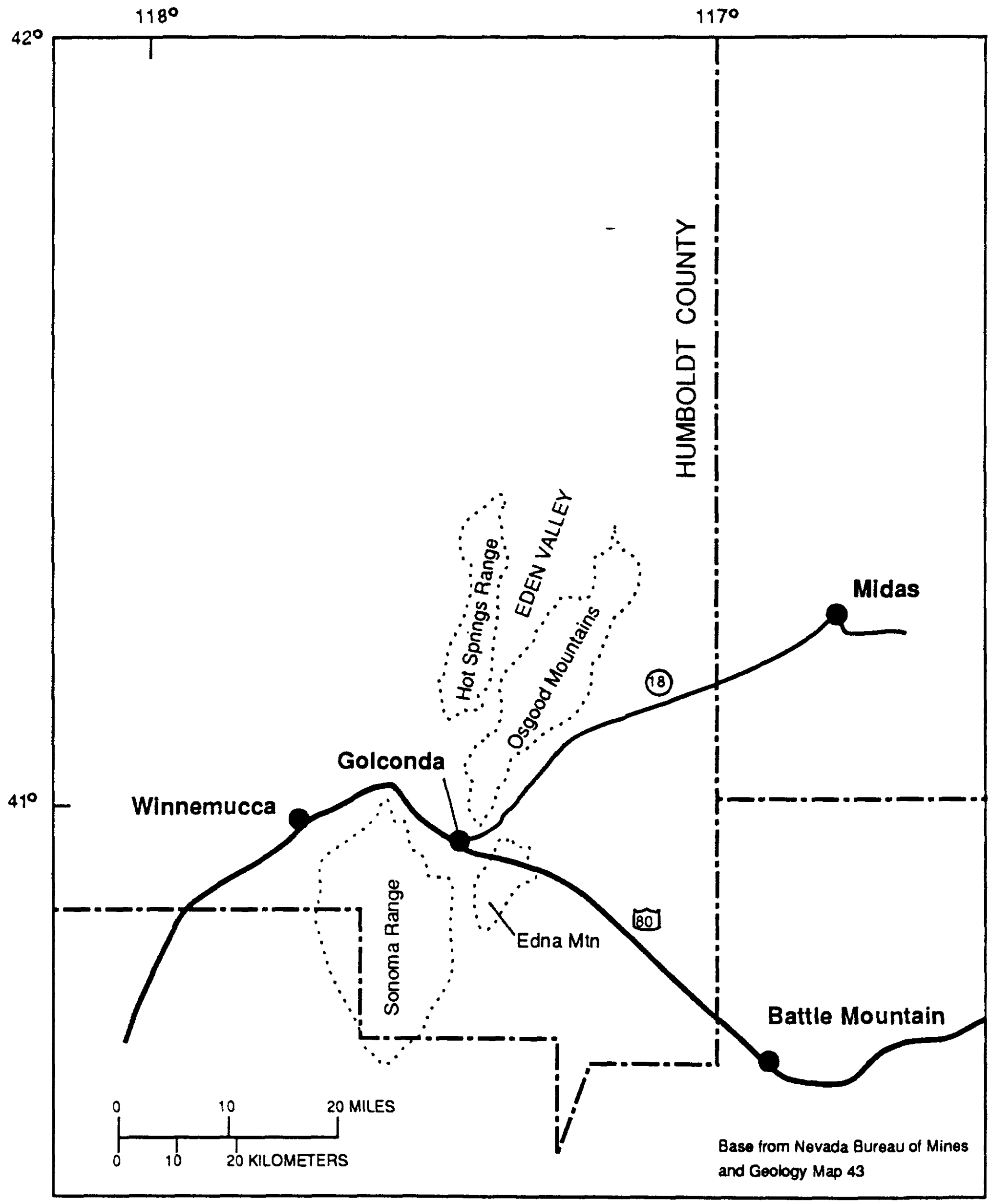
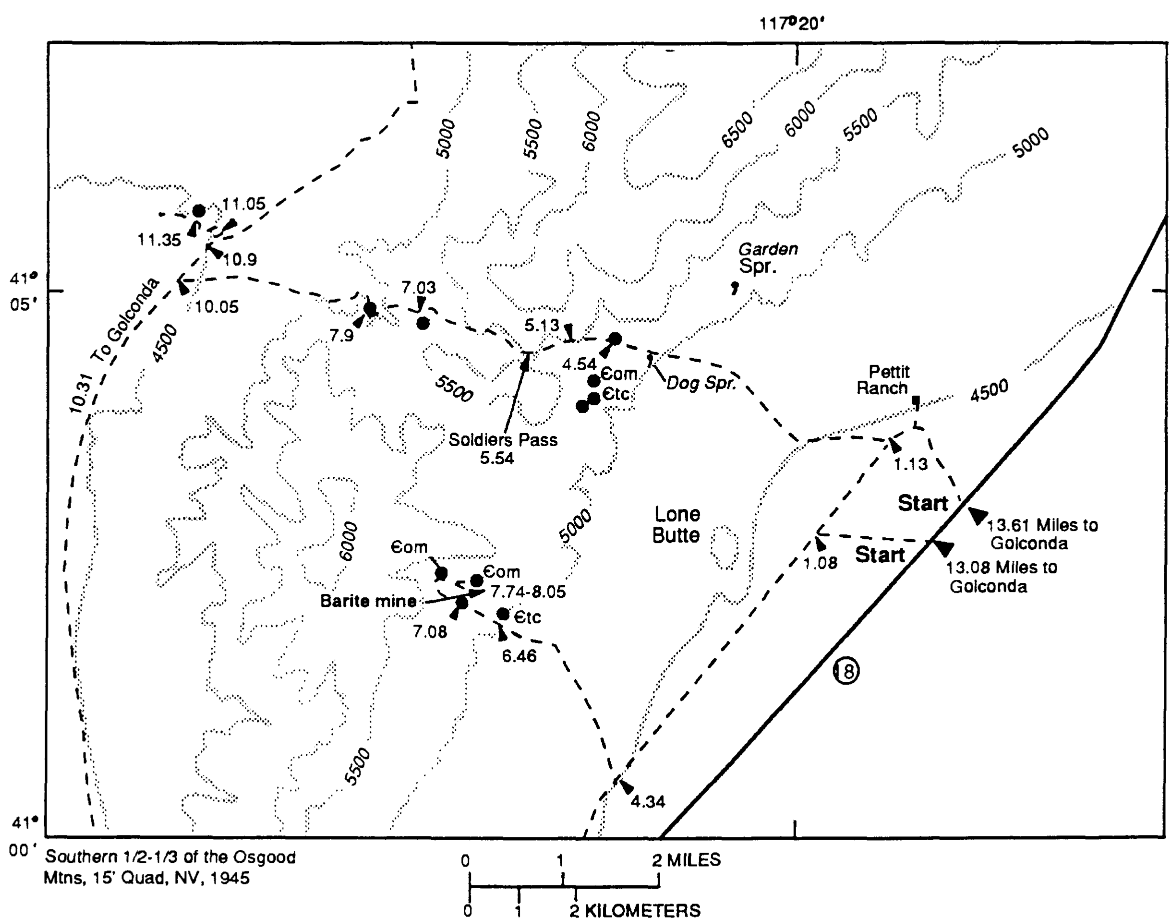
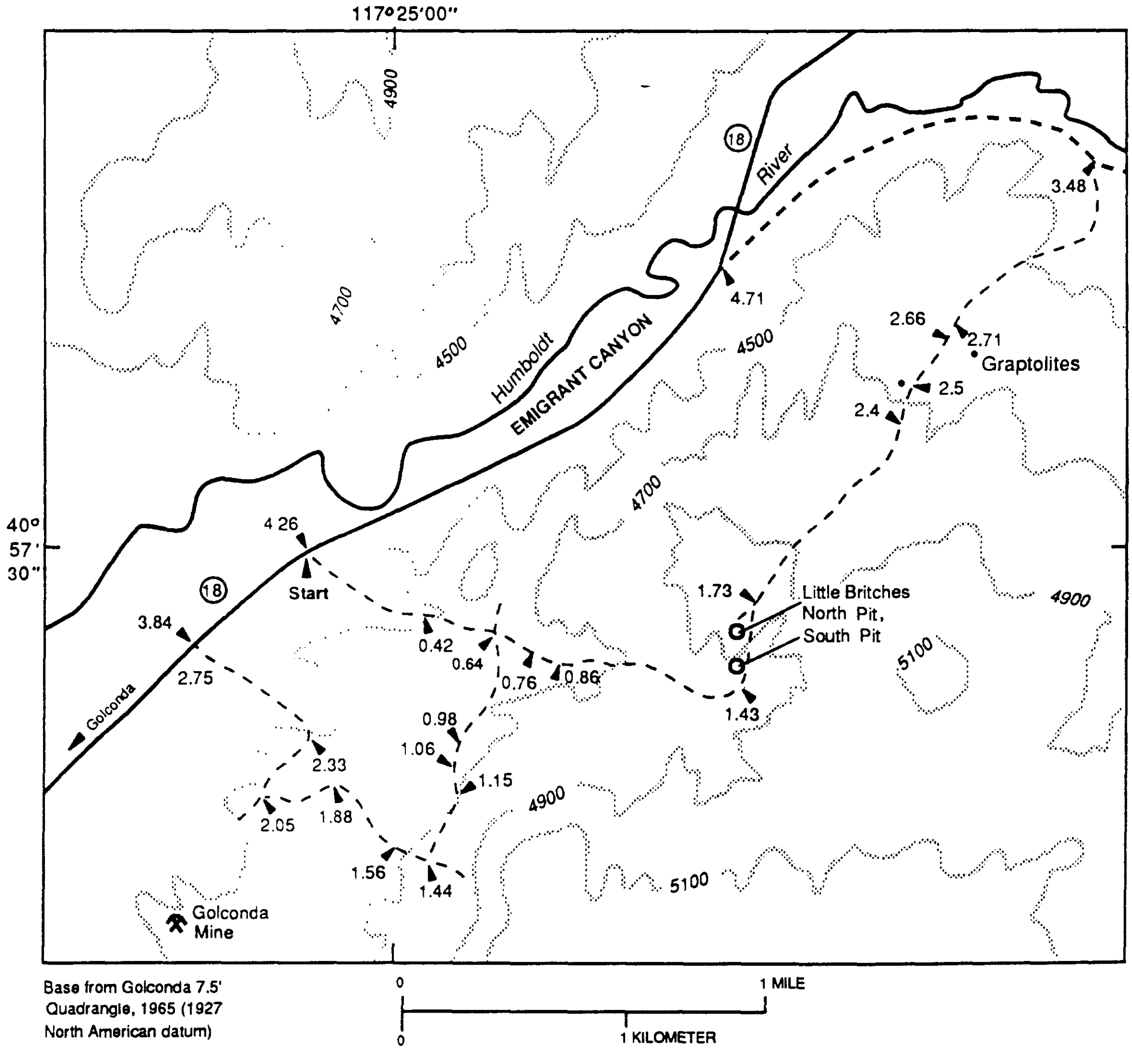


1. Location map showing mountain ranges in southern Humboldt County, Nevada.

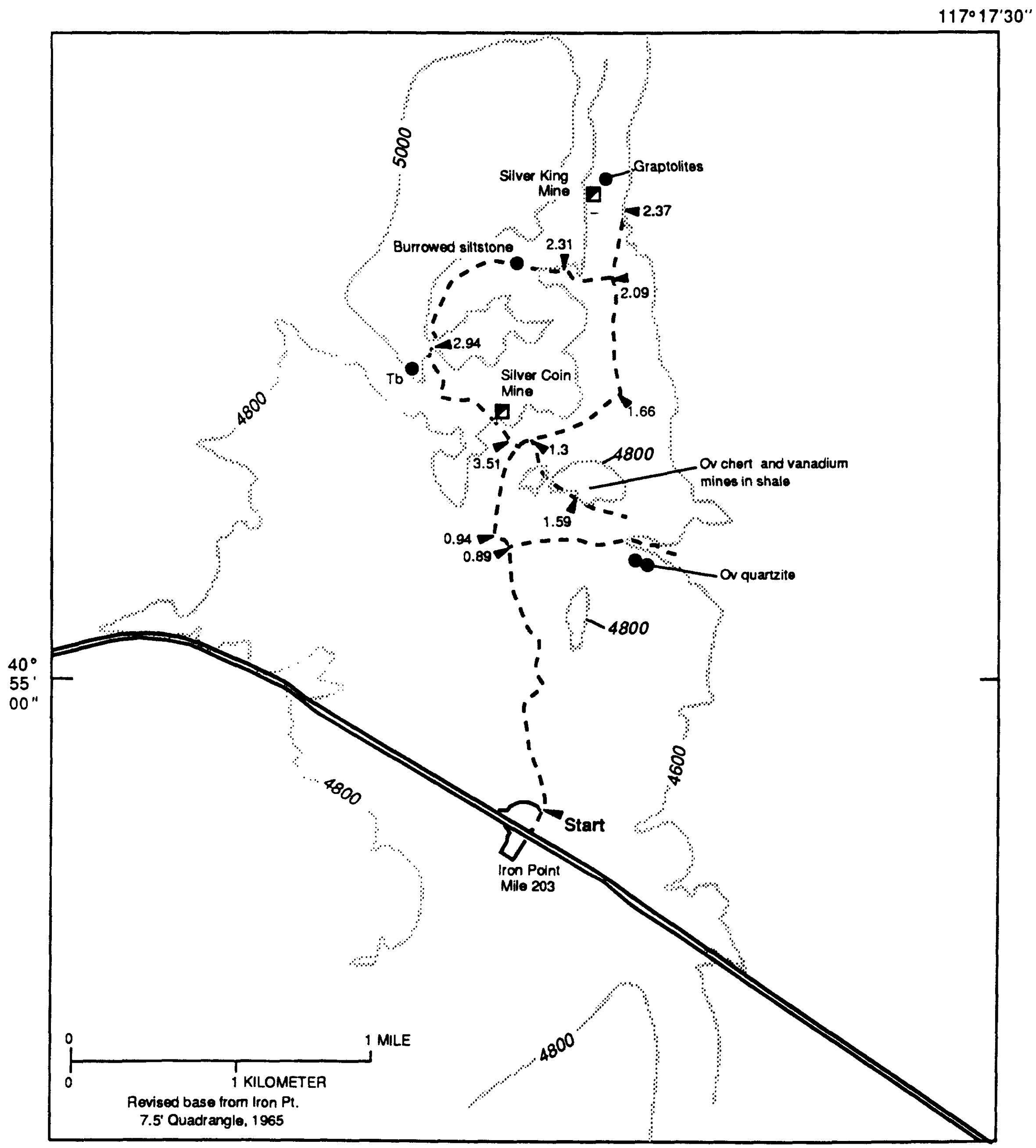


Southern 1/2-1/3 of the Osgood Mtns, 15' Quad, NV, 1945

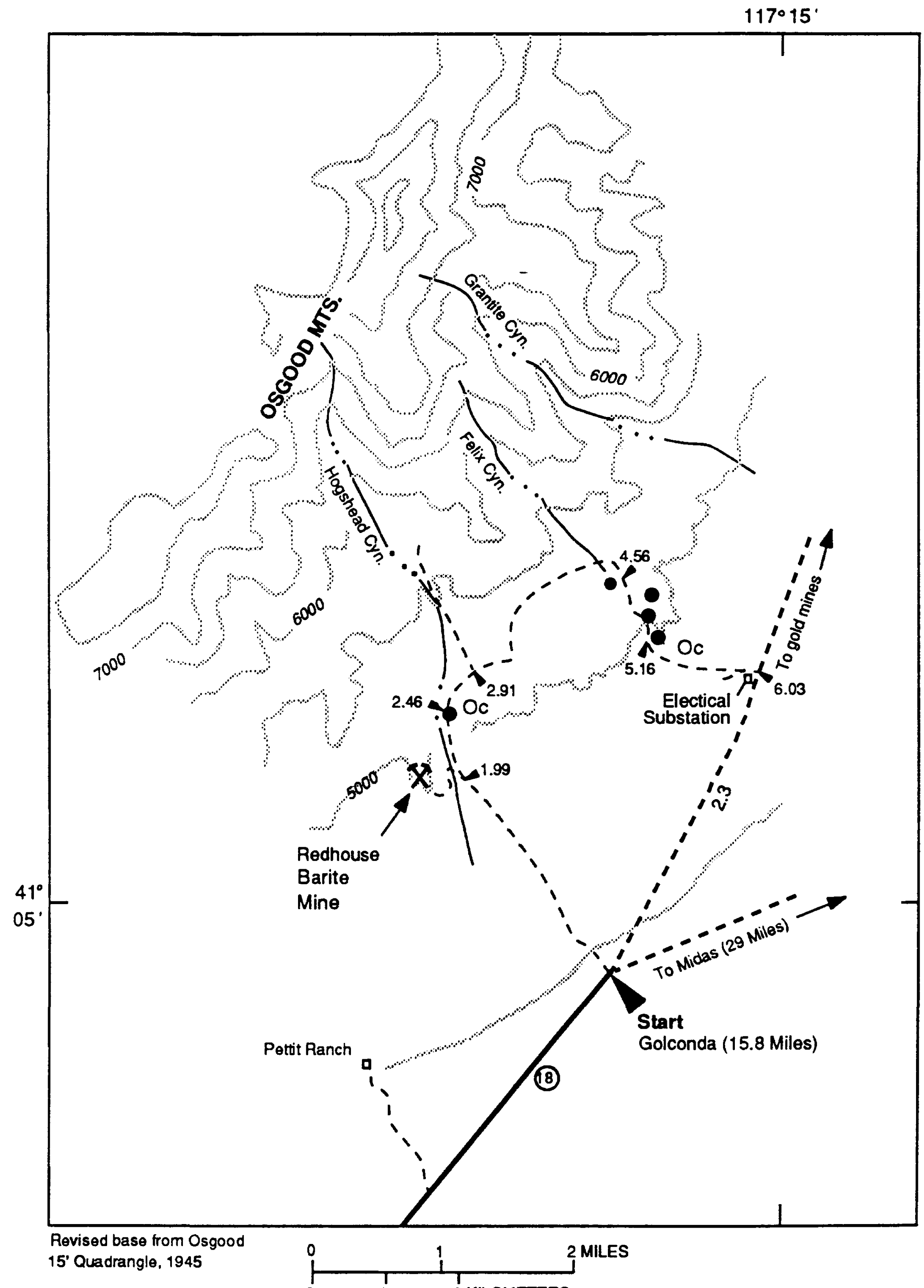
2. Roads through the Osgood Mountain Quartzite on Soldiers Pass and at a barite mine in the southern Osgood Mountains, and Valmy Formation in the southeastern Hot Springs Range.



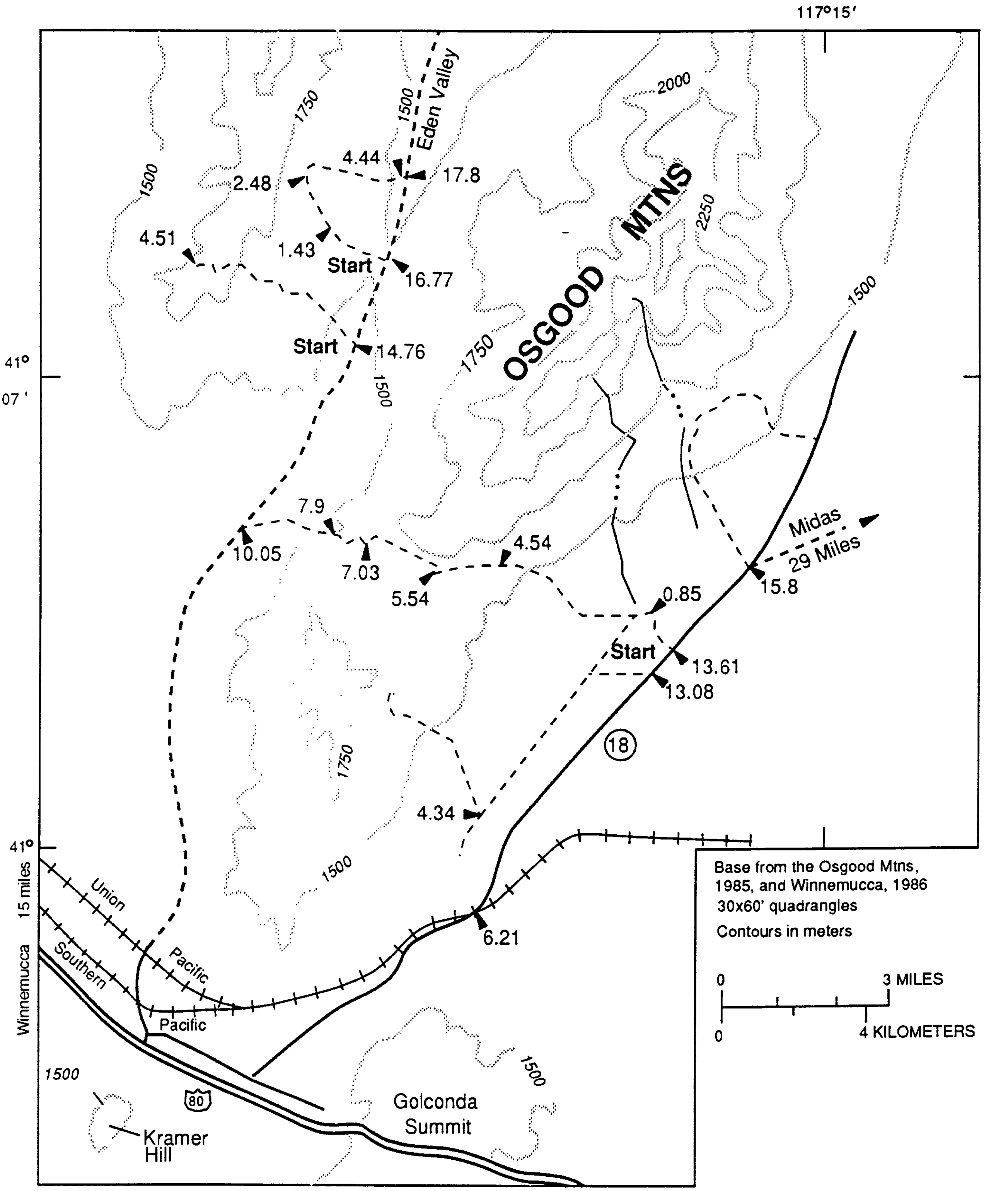
3. Roads through the Preble Formation south of Emigrant Canyon near the type locality, north side of Edna Mountain (Ferguson and others, 1951 and 1952).



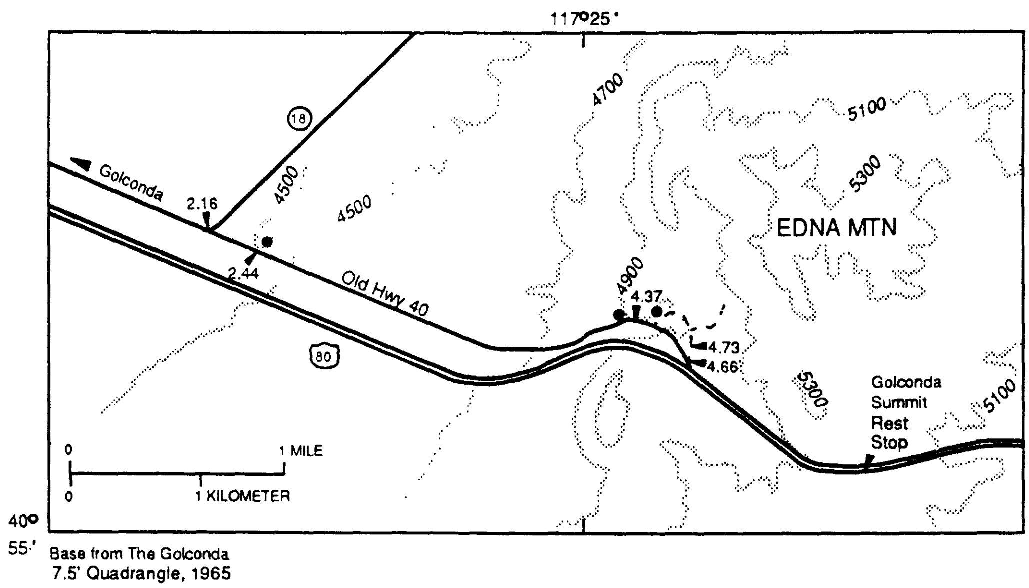
4. Roads through the Comus and Vinini Formations south of Iron Point, east side of Edna Mountain. This is the type area for the Comus Formation, (Ferguson and others, 1952).



5. Road to outcrops of the Comus Formation in Hogshead and Felix Canyons, east side of the Osgood Mountains.



6. Roads to outcrops of the Osgood Mountain Quartzite and Comus Formation in the Osgood Mountains, and the Valmy and Harmony Formations in the Hot Springs Range.



7. Road to the Golconda thrust and allochthon near Golconda Summit, Edna Mountain.