INITIAL RESULTS OF STRATIGRAPHIC AND STRUCTURAL FRAMEWORK STUDIES IN THE CEDARS QUADRANGLE, SOUTHERN SHOSHONE RANGE

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ABSTRACT

Stratigraphic, structural, and paleontological studies in The Cedars quadrangle in the southern Shoshone Range show that its geology is analogous to that of the Battle Mountain area. The structurally lowest units consist of deformed chert and quartzite of the Roberts Mountains allochthon. These rocks are unconformably overlain by a shoaling upward sequence, part of the overlap assemblage of Roberts (1964), composed of conglomeratic turbidites and overlying shelfal siltstone, shale, and sandstone that are correlative with the Pennsylvanian and Permian Antler sequence of the Battle Mountain area. A thin limestone at the base of the shelf deposits has yielded Late Pennsylvanian conodonts that are coeval in part with the Pennsylvanian and Permian Antler Peak Limestone, middle formation of the overlap sequence. Sedimentary features suggest that the overlap sequence in The Cedars quadrangle may comprise fan-delta deposits that were deposited in a more basinward position relative to the rocks of the Antler sequence in the Battle Mountain area.

The overlap sequence in The Cedars quadrangle is overlain on a structural contact by the Mississippian, Pennsylvanian, and Permian Havallah sequence of the Golconda allochthon. New radiolarian and conodont collections show that the Havallah consists of distinct lithological packages of Late Pennsylvanian and Permian siltstone and argillite and Middle and Late Pennsylvanian and Permian argillite and chert that probably once were deposited along the eastern, proximal margin of the Havallah basin. The structural contact between the overlap sequence and the Golconda allochthon suggest that it is correlative with the Golconda thrust. Our new paleontologic and structural data, however, do not support a thrust relation across the fault and instead suggest only stratal disruption in a homoclinal succession of strata. Several explanations are possible, including (**1**) the base of the Havallah sequence in The Cedars quadrangle is an extensional fault, possibly developed by submarine landsliding in the Permian, (**2**) the Golconda thrust is located higher in Havallah strata, requiring that Havallah strata compose part of the footwall as well as the hangingwall of the thrust, and (**3**) the uppermost, undated part of the overlap sequence in the footwall includes rocks that are younger (Permian?) than the dated Late Pennsylvanian limestone in the middle of the overlap sequence.

The Paleozoic rocks are overlain by a succession of Tertiary volcanic rocks including ash flow tuff and are cut by systems of generally north- and east-trending high-angle faults of Tertiary age. An episode of alteration marked by extensive silicification and liesegang banding is developed in the coarse-grained, lower part of the overlap sequence and is associated with north-striking faults.

The Cedars quadrangle is located along the western margin of the Battle Mountain-Eureka mineral trend and south of the southward projection of the pluton-related Ag-Au mineral deposits in the Battle Mountain area. The geology of The Cedars quadrangle displays many characteristics that mark mineral deposits in the Battle Mountain district, including (**1**) intersection of structural trends; (**2**) presence of north-striking normal faults, (**3**) presence or suspected presence of magmatic-hydrothermal systems, (**4**) presence of rocks of the Antler sequence as a receptive host; and (**5**) the presence of a fault similar to the Golconda thrust for sealing ascending hydrothermal fluids. These features suggest that The Cedars quadrangle provides an opportunity to test predictive models for distal disseminated gold-silver deposits in a region that is highly prospective for these types of deposits.

INTRODUCTION

The Cedars 7.5' quadrangle, located in the southern Shoshone Range about 60 km south of Battle Mountain in north-central Nevada (fig. 1), lies along the southwestern margin of the Battle Mountain-Eureka mineral trend (Roberts, 1966; Shawe, 1991). The quadrangle is located south of the south-striking porphyry-related and distal disseminated Ag-Au deposits in the Battle Mountain area (Doebrich and Theodore, 1996) and the Cove and McCoy deposits (Brooks and others, 1991), and it is west of the sediment-hosted Carlin-type Pipeline and Cortez deposits (Foo and others, 1996). Structurally-controlled zones of hydrothermal alteration are present in the The Cedars quadrangle and indicate a potential for presence of widespread mineralized rocks. The quadrangle has been actively explored by mining companies since the 1970’s as evidenced by numerous exploration roads, pits, drillpads, and other excavations, although no mines are located within its boundaries. Nonetheless, published geologic map

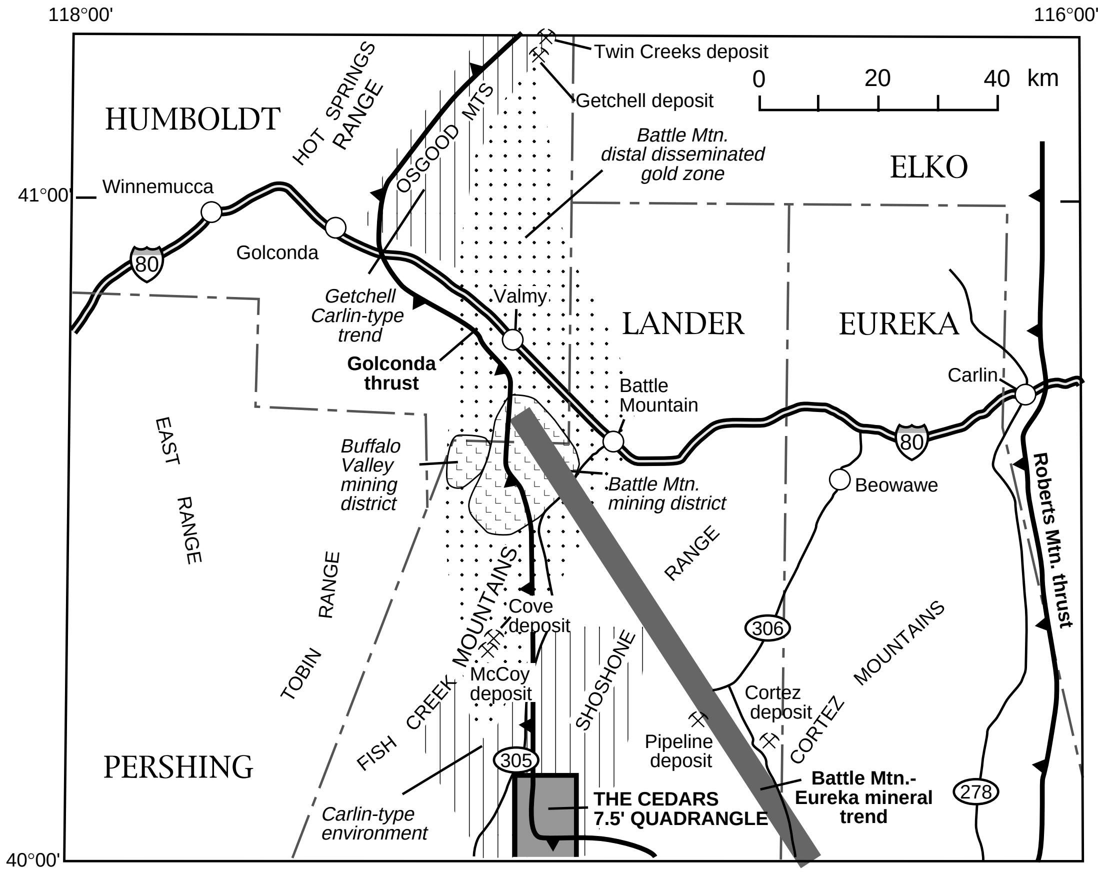

Figure 1. Index map for north-central Nevada showing the location of The Cedars quadrangle, the Battle Mountain mining district, the Battle Mountain-Eureka mineral trend, and locations mentioned in the text. Also shown is an inferred north-striking zone of distal disseminated gold deposits in the Battle Mountain area and the zone of Carlin-type deposits in the Osgood Mountains. A similar zone of Carlin-type deposits may be hypothesized to adjoin the southern margin of the Battle Mountain distal disseminated gold zone in the area of The Cedars quadrangle.

and other information from The Cedars quadrangle are sparse and limited to a reconnaissance 1:63,360–scale geologic map (McKee and Stewart, 1969) and smaller scale (1:250,000) regional geologic maps (Stewart and Carlson, 1976; Stewart and McKee, 1977). These maps indicate the stratigraphy of the Battle Mountain Mining District (Doebrich and Theodore, 1996), especially the Pennsylvanian and Permian Antler sequence, may be present in The Cedars quadrangle. Because rocks of the Antler sequence are the most favorable host for hydrothermal ore deposits in the Battle Mountain Mining District (Doebrich and Theodore, 1996), their presence would suggest potential for distal disseminated Ag-Au deposits. Alternatively, Carlin-type deposits may be present in The Cedars quadrangle if alteration is not associated with plutonic rocks.

This report presents stratigraphic and structural results of an ongoing geologic investigation in The Cedars quadrangle begun in the fall of 1996. Initial work is concentrated in the north-central part of the quadrangle, with geologic reconnaissance elsewhere in the quadrangle (fig. 2). This report includes new paleontologic data and stratigraphic observations that provide a basis for comparison with the stratigraphy of the Battle Mountain Mining District and other parts of north-central Nevada. These results and associated structural observations suggest that the framework geology of The Cedars quadrangle shares several key characteristics with the geology of the Battle Mountain Mining District.

GEOLOGIC SETTING

The northeast-trending ranges of north-central Nevada contain a structural stratigraphy that is regionally extensive in the western U.S. (Roberts and others, 1958; Silberling and Roberts, 1962; Roberts, 1964) (fig. 1). The uppermost structural unit is the Golconda allochthon, which consists of

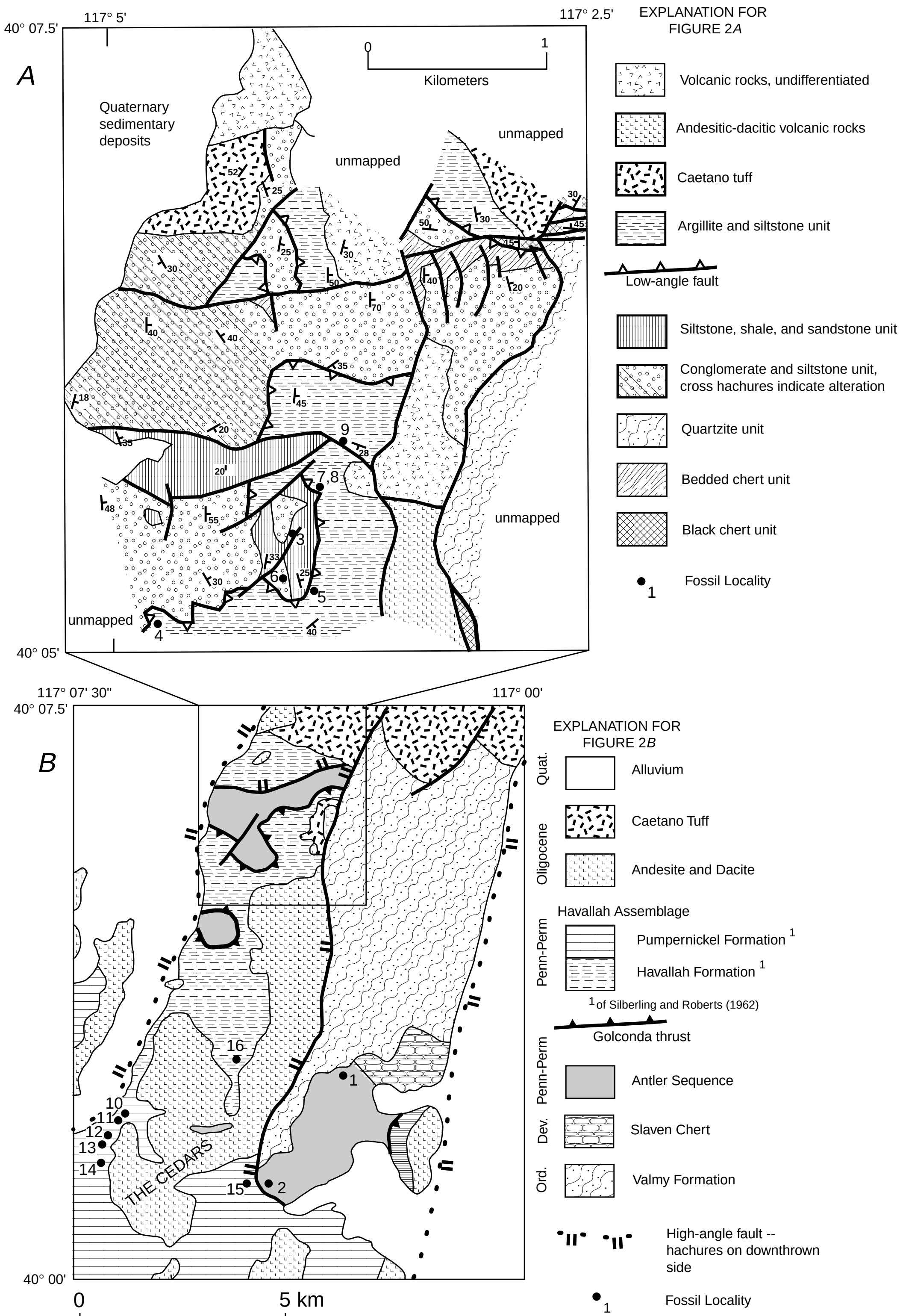

Figure 2. Geologic maps of The Cedars quadrangle. ***A***., Simplified geologic map of the north-central part of The Cedars quadrangle; ***B***., Generalized geologic map of The Cedars quadrangle modified from McKee and Stewart (1969), Stewart and Carlson (1976), and Stewart and McKee (1977).

deformed upper Paleozoic basinal rocks, including radiolarian chert, argillite, lithic sandstone, and mafic volcanic rocks. These rocks represent the deformed fill of a marginal basin that was thrust eastward on the Golconda thrust during the Permo-Triassic Sonoman orogeny (Silberling and Roberts, 1962; Burchfiel and Davis, 1972; Speed, 1979; Miller and others, 1992). The Golconda allochthon was emplaced onto an older allochthonous basinal assemblage, the Roberts Mountains allochthon, which consists of lower and middle Paleozoic quartz-rich sandstone, black shale, radiolarian chert, and mafic volcanic rocks. The Roberts Mountains allochthon was thrust eastward at least 100 km onto autochthonous lower and middle Paleozoic continental-shelf carbonate and clastic rocks of the miogeocline of the western North America during the mid-Paleozoic Antler orogeny. Following the Antler event, but prior to the emplacement of the Golconda allochthon, an overlapping succession of Upper Paleozoic coarse-grained clastic rocks, limestone, and fine-grained calcareous clastic rocks were deposited in angular unconformity on deformed rocks of the Roberts Mountains allochthon. The overlap sequence, thought to have been deposited in multiple local basins, was derived from local sources in highlands that developed during the Antler orogeny (Roberts and others, 1958). Stratigraphic relations of the overlap sequence are significant because they confirm that at least two contractional deformational episodes are represented in this part of north-central Nevada. These rocks are covered by Tertiary ash-flow tuffs and other volcanic rocks and cut by numerous high-angle faults related to Cenozoic extension in the Great Basin.

The Cedars quadrangle is located at the eastern margin of the Golconda allochthon in central Nevada (fig. 1). McKee and Stewart (1969) showed that the eastern limit of the allochthon in The Cedars quadrangle is delineated by a prominent north-striking high-angle fault (fig. 2). To the east of this fault are chert, shale, and quartzite of the Roberts Mountains allochthon, which they assigned to the Ordovician Valmy Formation and Devonian Slaven Chert. West and south of the fault, McKee and Stewart (1969) assigned rocks of the Golconda allochthon to the Pennsylvanian(?) Pumpernickel Formation and the Pennsylvanian and Permian Havallah Formation of Roberts (1964). Paleontological data from outside the quadrangle, however, have shown that the Pumpernickel and Havallah Formations are tectonic rather than lithostratigraphic units (Stewart and others, 1977; Murchey, 1990) and these formational assignments are now thought to have little or no stratigraphic significance. In contrast to McKee and Stewart (1969), the regional maps of Stewart and Carlson (1976) and Stewart and McKee (1977) showed areas of exposure of the overlap sequence in structural windows through the Golconda allochthon. This relation is of interest because one exploration model in the Battle Mountain Mining District suggests that coarse-grained deposits of the overlap sequence form host rocks for ore-bearing fluids that were trapped beneath the finer grained deposits of the Golconda allochthon (Doebrich and Theodore, 1990). Stewart and Carlson (1976) and Stewart and McKee (1977) also showed overlap sequence rocks in depositional contact on rocks of the Roberts Mountains allochthon east of the prominent north-trending high-angle fault. Thick ash flow tuffs of the Oligocene Caetano Tuff overlie Paleozoic rocks in the northern part of the quadrangle and volcanic rocks of unknown affinity overlie Paleozoic rocks in the southern part of the quadrangle.

LOCAL STRATIGRAPHY
Roberts Mountains allochthon

Rocks of the Roberts Mountains allochthon in The Cedars quadrangle were described by McKee and Stewart (1969) as "black chert, dark shale, and light and dark gray quartzite". They assigned most of these rocks to the Ordovician Valmy Formation but tentatively assigned thin-bedded black chert to the Devonian Slaven Chert in the southeastern part of the quadrangle (fig. 2*B*). No fossil localities have been reported from rocks of the Roberts Mountains allochthon in The Cedars quadrangle to confirm these lithologic correlations.

In the north-central part of The Cedars quadrangle (fig. 2*A*), we tentatively divide the Roberts Mountains allochthon

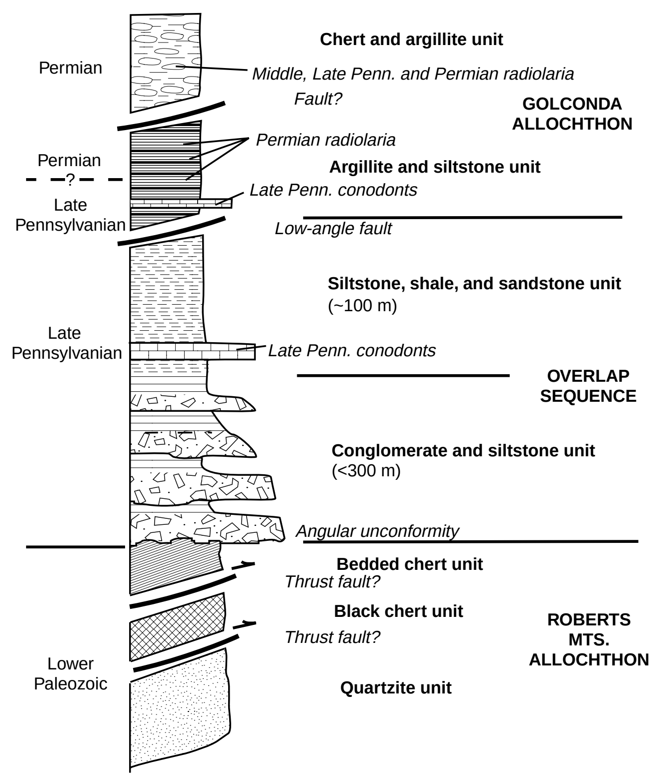

Figure 3. Generalized stratigraphic section for Paleozoic rocks of The Cedars quadrangle and known age relations.

into three units, which from base to top are quartzite, black chert, and bedded chert (fig. 3). These units are presumed to be structural units, although depositional relations may be revealed as more detailed mapping and paleontologic information become available.

The quartzite unit consists of massive medium gray to bluish gray fine-grained quartzite. Layering is commonly visible from a distance, but sedimentary structures, including bedding, are difficult to identify in outcrop-scale exposures. The quartzite unit has a structural thickness of several hundred meters, but may be repeated by folding and (or) faulting.

The black chert unit is thick bedded (5–20 cm thick) to massive, radiolarian-bearing, and displays few or no argillitic interbeds, lending a massive appearance to the unit. Bedding in the black chert unit is generally concordant to undulose and is only deformed locally into outcrop-scale folds. Local units of white and gray chert are associated with the black chert and display bedding characteristics similar to the black chert and thus are included in this unit. The stratigraphic thickness of the unit is uncertain but it has a structural thickness of about 100 m as presently mapped.

The bedded chert unit is conspicuously bedded in layers 2 to 5 cm thick and consists of gray and greenish-gray partially recrystallized chert which contains abundant radiolarians. Interbedded light to medium gray fissile argillite beds comprise 2 to 50 percent of the unit (fig. 4*A*). The bedded chert unit typically displays complex outcrop-scale folds that distinguish it from the black chert unit (fig. 4*B*). The difference in structural style may result from the presence of relatively less competent interlayered argillite in the bedded chert unit. The structural thickness of the unit is about 300 m, although the stratigraphic thickness of the unit is likely much less because of structural thickening caused by contractional deformation.

Overlap sequence

The overlap sequence rests in angular unconformity on rocks of the bedded chert unit of the Roberts Mountains allochthon in the north-central part of The Cedars quadrangle (figs. 2*A* and 5) and on quartzite and black argillite in at least two localities in the southern part of the quadrangle, east of the prominent north-striking high-angle fault in the middle of the quadrangle (Stewart and Carlson, 1976; Stewart and McKee, 1977) (fig. 2*B*). We have divided the overlap sequence into two units in the north-central part of the quadrangle (fig. 3). The lower unit consists of thick, massive intervals of gray chert-pebble conglomerate with interbedded intervals of thin-bedded quartz-rich siltstone (fig. 6). The upper unit consists of yellow brown siltstone, brown shale, and very fine-grained sandstone. A thin unit of fossiliferous limestone is locally present near the base of the upper unit.

Conglomerate in the conglomerate and siltstone unit contains abundant angular and subangular chert clasts and sparse quartzite clasts. Clasts in the conglomerate are locally as large as 6 cm, although clast sizes are less than 3 cm in most exposures. Bedding in the conglomerate is commonly massive or obscured by alteration, a common feature of the conglomerate and siltstone unit, but displays sharp, erosional bases and normal grading at the tops of beds where bedding is visible (fig. 7*A*). Conglomerate beds are 50 to 200 cm thick and commonly form amalgamated units as much as 20 m thick, particularly near the base of the unit. The conglomerate is typically framework supported, channelized, and cross bedding is rare or absent. Thin-bedded intervals of quartz siltstone as thick as 10 m thick are interbedded with the conglomerate and are apparently more common, thicker, and finer grained higher in the section. The thin-bedded intervals consist of light gray, laterally continuous beds of quartz siltstone and very fine-grained sandstone and sparse graded beds of conglomerate as thick as 1 m (fig. 7*B*). Ripple cross lamination is locally present in the siltstone. The consistent east dip of the conglomerate and siltstone unit coupled with its map distribution suggest that it has a thickness of over 1,200 m. However, as discussed in more detail below, the stratigraphic thickness of the unit is likely less than about 300 m because numerous west-dipping normal faults drop the section incrementally down to the west.

The overlying siltstone, shale and sandstone unit is typically poorly exposed, consisting of platy, chippy slightly calcareous sandstone and siltstone float. Thickness of the unit is uncertain because of poor exposure and structural control, but may be as much as 100 m. Outcrops of this unit consist of 1– to 2–m-thick intervals of parallel laminated to flaggy very fine-grained micaceous sandstone in thin-bedded to massive gray argillite. The sandstone intervals consist of thickening upward cycles composed of sandstone beds (fig. 8). Bioturbation is very abundant and commonly obscures sedimentary structures. Where visible, sandstone beds are laterally continuous and display erosional bases, slight normal grading, and current and wave rippled tops (fig. 8). In a few places just above the base of the siltstone, shale, and sandstone unit is a distinctive interval of calcareous siltstone, sandstone, and sandy limestone as much as 10 m thick. The sandy limestone beds, as much as 1 m thick, consist of normally graded fossiliferous grainstone with an abundant and diverse megafaunal and trace fossil assemblages (figs. 3). In one location (map locality 3, table 1, fig. 2*A*), the limestone yielded a diverse conodont assemblage, including indigenous Late Missourian conodonts and redeposited middle Osagean and Atokan conodonts (A. Harris, written comm., 1996).

Sedimentary structures in the overlap sequence suggest deposition in a marine setting. Beds in the thin-bedded intervals in the conglomerate and siltstone unit consistently have erosional bases, lateral continuity, and sedimentary structures indicative of deposition by turbidity currents and other sediment-gravity flows. Sponge spicules in siltstone

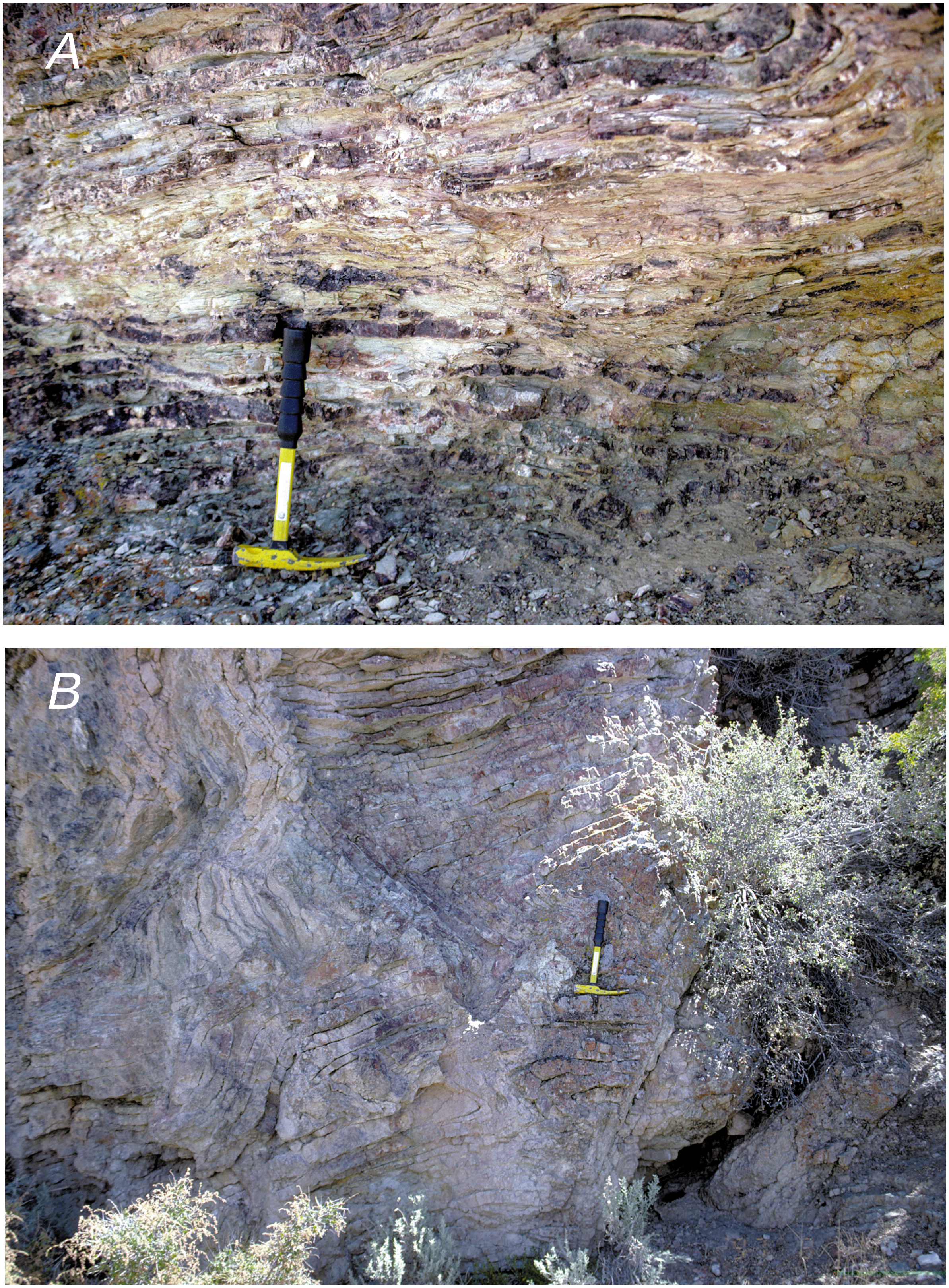

Figure 4. Photographs of bedded chert unit of bedded chert unit in the Roberts Mountains allochthon. ***A***., interbedded chert and argillite; ***B***., disharmonic folds, suggesting structural transport to left (northward)

Figure 5. Photograph of conglomerate in conglomerate and siltstone unit resting in angular unconformity on chert of the bedded chert unit (contact at hammar).

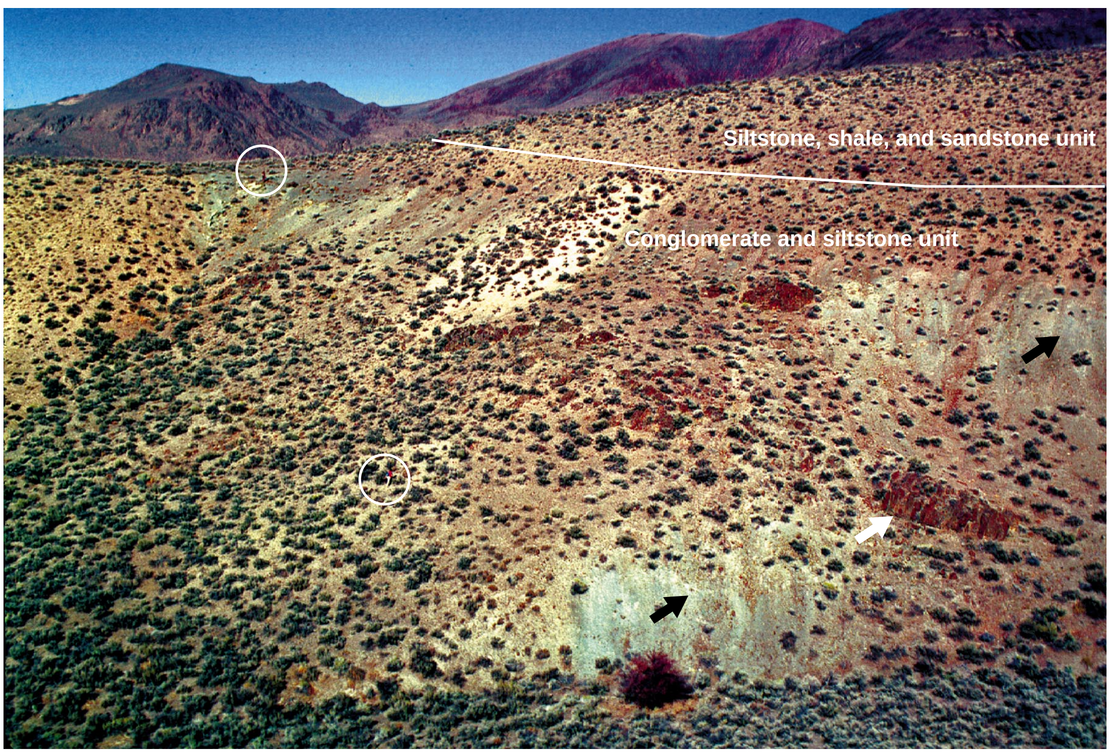

Figure 6. Northeastward view of contact between conglomerate and siltstone and siltstone, shale, and sandstone units of overlap sequence. Bold outcrops in conglomerate and siltstone unit are conglomeratic intervals. White arrow, for example, indicates part of a conglomerate interval that can be traced discontinously up hill to left toward higher geologist. Light-colored areas of float are siltstone intervals (for example, at black arrows). Fossiliferous limestone is present at top of hill in siltstone, shale, and sandstone unit. Circles indicate geologists for scale.

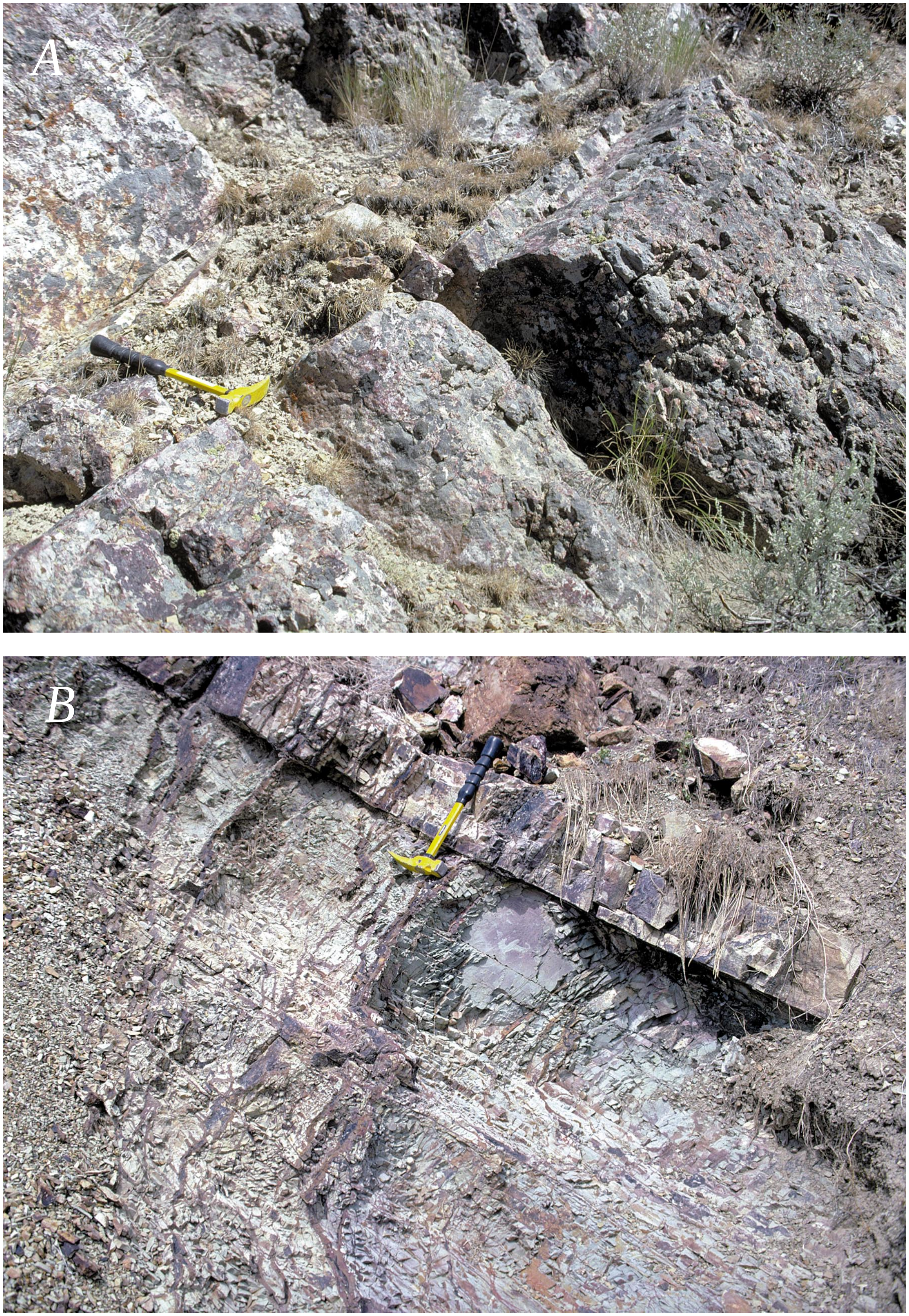

Figure 7. Photographs of conglomerate and siltstone unit of overlap sequence. ***A***., Thin zone of normal grading (at hammar head) at top of conglomerate bed; ***B***., Thin-bedded siltstone and fine-grained sandstone of siltstone interval. Note sharp, planar bases of beds.

Figure 8. Photograph of thickening upward sequence of calcareous sandstone in siltstone, shale, and sandstone unit of overlap sequence. Uppermost bed displays wave ripples indicative of deposition above wave base.

(map locality 6, table 1, fig. 2) of the conglomerate and siltstone unit also indicate a marine origin. The dominantly coarse-grained amalgamated and channelized deposits of angular debris at the base of the succession suggest deposition as coarse grained turbidites or other sediment-gravity flow deposits on a submarine fan of unknown extent. The change upward in the sequence to the overlying siltstone, shale and sandstone unit indicates waning sedimentation under marine conditions. The ubiquitous bioturbation, calcareous composition, and presence of wave ripples in the upper unit suggest deposition above wave base in a shelf setting. Sedimentary structures observed in sandstone in the upper unit are similar to tempestite deposits, which result from wind and wave-induced storm flow, whereas the argillite records suspension sedimentation between storm events. These preliminary observations suggest that the overlap sequence in The Cedars quadrangle records shoaling conditions.

Golconda allochthon

The Golconda allochthon in The Cedars quadrangle rests in structural contact on rocks of the overlap sequence on a prominent fault that is analogous in its structural position to the Golconda thrust (Stewart and Carlson, 1976; Stewart and McKee, 1977). Rocks of the allochthon consist dominantly of poorly exposed thin-bedded argillite and siltstone with local interleaved lenticular bodies of chert. We tentatively subdivide these rocks into two principal lithologic associations, including (**1**) an argillite and siltstone unit and (**2**) chert and argillite unit (fig. 3). These units correspond in general to the rocks previously assigned to the Havallah and Pumpernickel Formations, respectively, (McKee and Stewart, 1969; Stewart and Carlson, 1976; Stewart and McKee, 1977) but the units are likely structural rather than stratigraphic units as interpreted by earlier workers. For this reason, we refer to the upper Paleozoic strata of the Golconda allochthon as the Havallah sequence following the usage of Murchey (1990) rather than using the older formal stratigraphic nomenclature for these rocks.

All rocks of the Golconda allochthon in the north-central part of The Cedars quadrangle are included in the argillite and siltstone unit. This unit consists of even, graded beds of light to dark gray siliceous argillite, silty argillite, siltstone, shale, and very fine-grained quartz-rich sandstone (fig. 9). In outcrop, these strata are laterally continuous with beds typically less than 10 cm thick. Coarse-grained sandstone and granule conglomerate are present locally as sparse, isolated 5– to 10–

Table 1. Fossil locality information for the Cedars quadrangle.

Map location	Sample number	Field locality number	Latitude	Longitude	Unit	Fossil type	Age
1	96TM-155A	96TM-155A	40° 02.71'	117° 03.20'	Overlap sequence	Conodonts[1]	Redeposited? Llandoverian (Early Silurian) to late Emsian (Early Devonian)
2	16039-49J	16039-49J	40° 01'	117° 05.'	Overlap sequence or Havallah sequence[2]	Conodonts[3]	late early Desmoinesian (late Middle Pennsylvanian)
3	96MY-4	96MY-4	40° 05.53'	117° 04.19'	Siltstone, shale, and sandstone unit, overlap sequence	Conodonts[4]	Indigenous late Missourian (middle Late Pennsylvanian); includes redeposited middle Osagean (Lower Mississippian) and Atokan (Middle Pennsylvanian)
4	97TM-262D2	97TM-262	40° 05.06'	117° 04.90'	Argillite and siltstone unit, Havallah sequence	Conodonts[4]	Indigenous late Missourian to early Virgilian (middle Late Pennsylvanian); includes redeposited Early Mississippian
5	96MY-009	96TM-115	40° 05.25'	117° 04.06'	Argillite and siltstone unit, Havallah sequence	Radiolarians	Leonardian or Guadalupian (late Early or early Late Permian)
6	96MY-010	96TM-118	40° 05.30'	117° 04.15'	Conglomerate and siltstone unit[6], overlap sequence	Sponge spicules	Phanerozoic
7	96MY-011	96TM-120	40° 05.63'	117° 03.97'	Argillite and siltstone unit, Havallah sequence	Radiolarians	late Leonardian (late Early Permian)
8	96MY-012	96TM-121	40° 05.70'	117° 04.03'	Argillite and siltstone unit, Havallah sequence	Radiolarians, Sponge spicules	Phanerozoic
9	96MY-016A	96TM-125	40° 05.82'	117° 03.71'--	Argillite and siltstone unit, Havallah sequence	Radiolarians	late Leonardian (late Early Permian)
10	96MY-020	96TM-137	40° 01.01'	117° 06.80'	Chert and argillite unit, Havallah sequence	Radiolarians	Atokan? or Desmoinesian (Middle Pennsylvanian)
11	96MY-021	96TM-138	40° 02.29'	117° 07.09'	Chert and argillite unit, Havallah sequence	Radiolarians	Atokan? or Desmoinesian (Middle Pennsylvanian)
12	96MY-023	96TM-141	40° 01.99'	117° 06.94'	Chert and argillite unit, Havallah sequence	Radiolarians	Missourian to Wolfcampian (Late Pennsylvanian to early Early Permian)
13	96MY-024	96TM-142	40° 01.75'	117° 06.99'	Chert and argillite unit, Havallah sequence	Sponge spicules	Probable Guadalupian (early Late Permian)
14	96MY-028	96TM-146	40° 01.54'	117° 07.12'	Chert and argillite unit, Havallah sequence	Radiolarians	Leonardian (late Early Permian)
15	96MY-031	96MY-031	40° 01.61'	117° 04.56'	Chert and argillite unit, Havallah sequence	Radiolarians	late Leonardian to Guadalupian (late Early Permian to early Late Permian)
16	96MY-032	96TM-154A	40° 02.63'	117° 04.62'	Chert and argillite unit, Havallah sequence	Radiolarians	Leonardian (late Early Permian)

[1]Identified by A.G. Harris, U.S. Geological Survey, report WMRT-97-1

[2]Reported as Havallah Formation or Antler sequence (Overlap sequence) by Stewart and McKee (1977), p. 27.

[3]Originally identified by J.W. Huddle in report SW-69-3; Updated by A.G. Harris and B.R. Wardlaw, U.S. Geological Survey, report WMRT-96-3

[4]Identified by A.G. Harris and B.R. Wardlaw, U.S. Geological Survey, report WMRT-97-2

[5]Identified by A.G. Harris and B.R. Wardlaw, U.S. Geological Survey, report WMRT-96-4

[6]Sample collected from siltstone interval

Figure 9. Photograph of thin-bedded siltstone in siltstone and argillite unit of Golconda allochthon. Note sharp bases and normal grading of beds. Buckle on back pack at extreme lower left (circle) is 5 cm in length.

cm-thick beds. The sandstone beds consist principally of chert, quartzite, and argillite grains. Rare beds of bioclastic limestone and calcareous siltstone also are present. One limestone bed consists of sandy packstone that has yielded a diverse conodont assemblage, including apparently indigenous late Missourian or early Virgilian conodonts and redeposited Early Mississippian conodonts (A. Harris, written comm., 1997) (map locality 4, table 1 and figs. 2, 10).

Like the argillite and siltstone unit, the chert and argillite unit contains abundant argillite, but is more siliceous than the argillite and siltstone unit. Stewart and McKee (1977) considered it a different map unit (their Pumpernickel Formation (fig. 2*B*)), although they showed the nature of the contact between the siltstone and argillite unit (Havallah Formation of Stewart and McKee (1977)) as uncertain. A reconnaissance examination of the chert and argillite unit in the southwestern part of The Cedars quadrangle indicates that it consists dominantly of thin-bedded siliceous argillite with subordinate packages of red-brown siltstone and very fine sandstone, pink claystone, radiolarian chert that is red, green, or black, and greenish gray sponge–spicule chert. Chert bodies commonly are 2– to 10–m thick and compose about 20 percent of the unit. Quartz-rich sandstone beds, as thick as 10 cm, are locally present in the argillite and display sharp basal contacts, lateral continuity, graded bedding, current ripple cross lamination and other features typical of thin-bedded turbidites.

Radiolarians are the most common index fossils in the argillite and siltstone unit as well as the chert and argillite unit. They are found in bedded chert, siliceous argillite, and siliceous mudstone. Studies of radiolarians in the Golconda allochthon in the Battle Mountain area and in the eastern Tobin Range have determined the stratigraphic ranges of nine Early Mississippian (middle Osagean) to early Late Permian (early Guadalupian) radiolarian assemblages (Murchey, 1989; 1990). The radiolarian faunas of our study area have not been previously studied but systematic high-density radiolarian-dating in other map areas has proven that the Golconda allochthon is characteristically imbricated by multiple thrust faults at all scales (Miller and others, 1982, 1984; Snyder and Brueckner, 1983; Brueckner and Snyder, 1985; Stewart and others, 1986; Murchey, 1990; Tomlinson, 1990).

The location of twelve new microfossil localities from the Havallah sequence in The Cedars quadrangle are shown in table 1 and figure 2. Also shown in table 1 and figure 2 is a previously collected conodont sample (map locality 2) taken from what may be Havallah or possibly the overlap sequence (Stewart and McKee, 1977, p. 27). We tentatively assign this sample to the overlap sequence. Of these localities, ten

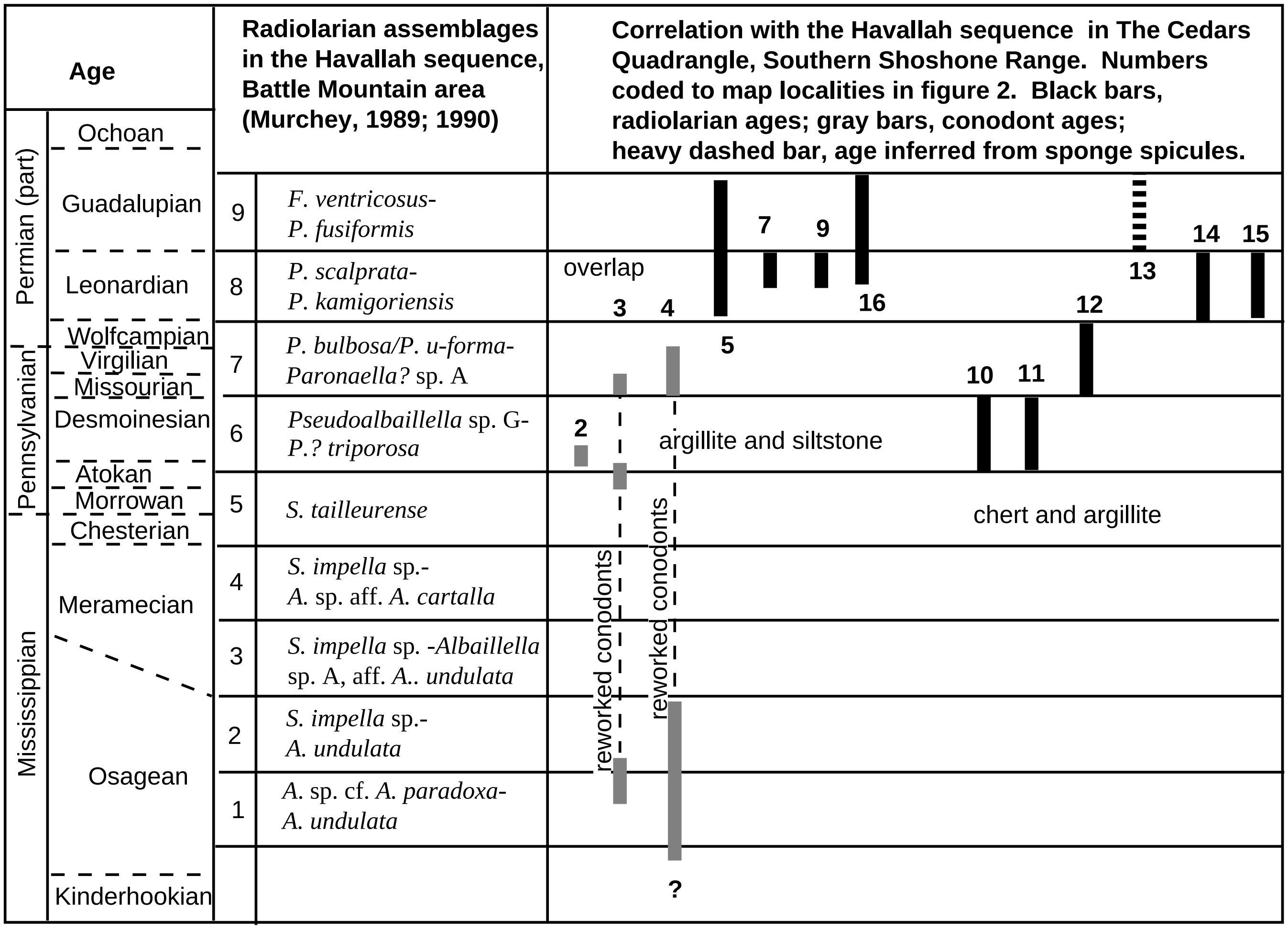

Figure 10. Age ranges of conodont and radiolarian assemblages from the Golconda allochthon in The Cedars quadrangle. Note that dated samples from the argillite and siltstone unit are younger than overlap sequence samples, suggesting that low-angle fault between these units may not have thrust relations. Chert and argillite unit of Golconda allochthon, however, contains assemblages that are older than overlap sequence and the argillite and siltstone unit suggesting that it could have been thrust onto these units.

contained radiolarian assemblages, two contained conodonts, and one contains only sponge spicules. The radiolarian faunas in these samples are correlated in figure 10 with the nine Early Mississippian (middle Osagean) to early Late Permian (early Guadalupian) radiolarian assemblages established in the Havallah sequence in the Battle Mountain area and the Tobin Range by Murchey (1989; 1990). The conodont samples from the Havallah sequence and overlap sequence also are shown for comparison on figure 10. Of the 11 samples of siliceous fauna from the Havallah, four were collected from the argillite and siltstone unit, whereas seven were collected from the chert and argillite unit. The details of these samples are as follows:

The argillite and siltstone unit in the north-central part of the quadrangle (fig. 2*A*) contains radiolarians as well as delicate sponge spicules. Map localities 7 (tan and green, chippy siliceous mudstone), 9 (alternating bedded siliceous argillite, siltstone, and shale; see fig. 9), and 16 (green siliceous mudstone beds to as much as 2 cm thick within a predominantly shale and argillite section) contain radiolarian faunas with elements characteristic of the younger part of the Leonardian *Pseudoalbaillella scalprata-Pseudotormentus kamigoriensis* assemblage of Murchey (1989, 1990). Map locality 5 (green siliceous argillite) has elements of the Leonardian *P. scalprata-P. kamigoriensis* or early Guadalupian *Follicucullus ventricosus-Pseudoalbaillella fusiformis* assemblages. Map locality 15 (float collection of green siliceous argillite, laminated black chert; tentatively included in the "Pumpernickel Formation" in map figure 2*B*) is on strike with the samples above and contains the early Guadalupian radiolarian *P. fusiformis*. The Permian radiolarian faunas recovered thus far from the argillite and siltstone unit postdate the youngest conodonts ages, Late Pennsylvanian, obtained from the quadrangle from either the argillite and siltstone unit (sample 4) or the structurally underlying overlap sequence (map locality 3 in the siltstone, shale, and sandstone unit).

Based on preliminary examinations of the Permian faunas, the relative abundance patterns of sponge spicule and radiolarian faunal groups are similar to those found in faunas from siliceous argillite and mudstone in the structurally lowest thrust-bounded package of the Havallah sequence in the Battle Mountain area (Lithotectonic Unit 1 of Murchey (1990)). Stauraxon radiolarians are more abundant than Albaillellaria in all samples and delicate sponge spicules are more abundant than radiolarians in some sieve residues. A high ratio of stauraxon radiolarians to Albaillellaria is characteristic of relatively deep marginal marine basins in the arc and back arc regions of the Permian Cordillera, but not of the open ocean region to the west (Murchey and Jones, 1993). For similar sponge spicule faunas in the Battle Mountain area, based on spicule morphotypes, relative abundance, and hemipelagic character of host strata, Murchey (1989, 1990) inferred a basin depth between 150 m and 1,000 m.

Samples from the chert and argillite unit were collected from the southern part of The Cedars quadrangle. Localities 10 to 14, collected on a north-south traverse south of Wood Canyon, yielded radiolarian and sponge spicule faunas ranging in age from Middle Pennsylvanian (Desmoinesian) to probable early Late Permian (early Guadalupian?). Localities 10 (green siliceous argillite) and 11 (black chert float) contain faunal elements of the late Middle Pennsylvanian *Pseudoalbaillella* sp. G - *Paronaella? triporosa* fauna of Murchey (1990). Significantly, these faunas are older than the Late Pennsylvanian conodonts in sample 3 of the overlap sequence. Locality 12 (green and maroon siliceous mudstone interbedded with maroon argillite) contains *Pseudoalbaillella bulbosa* and has a possible range from Missourian to Wolfcampian. Sample 14 (bedded green-gray chert with 1– to 2–cm thick beds) contains faunal elements characteristic of the Leonardian *P. scalprata - P. kamigoriensis* assemblage of Murchey (1990). Delicate but fairly diverse sponge spicule assemblages are present with the radiolarian faunas. Based on the paleobathymetric model of Murchey (1989, 1990), the radiolarian-bearing samples were deposited at depths between 150 m and 1,000 m, in a setting possibly deeper and (or) more distal than the depositional site of the argillite and siltstone unit.

Map locality 13 (2 cm bed of black chert) is a sponge spiculite with no radiolarians. The fauna is distinctive for its large monaxons, bean-like rhaxes, strongyles, and round sterrasters. Rhax-bearing spicule faunas appear to be confined to an early Guadalupian depositional belt extending from the Permian Phosphoria basin in Idaho southward down the trend of the Antler Highlands and eastern Golconda allochthon. The faunas are found in autochthonous shallow marine siltstones of the Permian Edna Mountain Formation near Battle Mountain (Murchey and others, 1995) and black bedded chert of the coeval Phosphoria Formation of southern Idaho (Murchey, 1989). These types of spicule faunas are present in black chert and cherty limestone turbidites of the eastern part of the Havallah sequence elsewhere from northern Nevada (Murchey, 1989,1990) to at least as far south as the Reese River area in the southern Shoshone Range (Tomlinson, 1990). In the autochthonous rocks of the Phosphoria basin and Antler Highlands and the allochthonous rocks of the Golconda allochthon, the rhax-bearing faunas are spatially associated with phosphatic sandstone or siltstone and the large monaxon spicules are commonly infilled with phosphatic material. We interpret the spicule faunas of locality 13 as a redeposited assemblage probably derived from the lower Guadalupian Edna Mountain Formation or equivalent unit somewhere along the trend of the Antler Highlands. In the north-central part of The Cedars quadrangle, however, we have not recognized overlap sequence rocks that are as young as Guadalupian or that contain rhax spicule faunas.

Tertiary rocks

Tertiary rocks in The Cedars quadrangle consist entirely of intermediate and felsic volcanic rocks. In the northern part of the quadrangle, the volcanic rocks consist of a thick sequence of light gray ash–flow tuff that has been mapped as the Oligocene Caetano Tuff (McKee and Stewart, 1969; Stewart and Carlson, 1976; Stewart and McKee, 1977). These rocks are at least 250 m thick and, at their base, consist of crystal-poor tuff with well developed eutaxitic texture. To the south, these tuffs thin dramatically, possibly due to faulting or irregular topography beneath the tuff. In the southern part of the quadrangle, volcanic rocks consist of red-brown-weathering, porphyritic plagioclase-biotite andesitic or dacitic flows that display a characteristic flaggy planar fabric. The porphyritic volcanic rocks are at least 400 m thick and are exposed over a broad area but are undated. The relation between the Caetano ash-flow tuff and the porphyritic volcanic rocks in the southern part of The Cedars quadrangle is presently unknown. Outcrops of black vitrophyre, crystal-rich tuff and pink weathering densely welded tuff are present in the intervening area. Some of these rocks have been correlated with the Miocene Bates Mountain tuff; others with the Caetano Tuff (Stewart and McKee, 1977). Stratigraphic studies, geochemical analysis, and Ar–Ar age dating of these volcanic units currently are in progress.

STRUCTURAL RELATIONS

The structural geology of The Cedars quadrangle is complex in detail and the observations reported here represent only initial results. Nonetheless, our studies to date allow classification of structures into several categories and determination of a few preliminary conclusions. We discuss separately below structures in The Cedars quadrangle associated with (**1**), the Roberts Mountains allochthon; (**2**) the Golconda "thrust" and allochthon; and (**3**) high-angle faults.

Roberts Mountains allochthon

Rocks of the Roberts Mountains allochthon display contractional structures at both outcrop and map scale. Outcrop-scale structures are well developed in the bedded chert unit, which exhibits abundant disharmonic folds (fig. 4*B*). Folds are open to tight and vary in style from chevron to strongly asymmetric. Small-displacement thrust faults and zones of brecciation disrupt the folds. Asymmetric folds at one locality indicate northward structural transport, with axial planes that strike N65°E and dip to the south. In contrast to the bedded chert unit, the black chert unit displays few outcrop-scale folds. This unit lacks argillite interbeds which allow disharmonic folding in the bedded chert unit and instead appears to have deformed as a rigid beam by faulting.

At map scale, the lithologic units that comprise the Roberts Mountains allochthon in the north-central part of The Cedars quadrangle dip moderately to the west. Contacts between these units are thought to be thrust faults, although critical evidence that demonstrate these relations have not yet been established. Radiolarian fauna in the chert are currently being processed to test this hypothesis.

Golconda thrust and allochthon

Rocks of the Golconda allochthon in the north-central part of The Cedars quadrangle are separated from overlap sequence rocks by a poorly exposed, yet prominent fault that dips about 30° to the east (figs. 2 and 11). This fault, which has been correlated with the Golconda thrust (Stewart and Carlson, 1976; Stewart and McKee, 1977), is located at a stratigraphic position that is near the base or within the upper, siltstone, shale and sandstone unit of the overlap sequence. The fault is commonly marked by a 10–m-thick zone of dark scaly argillite and, where the conglomerate and siltstone unit is in the footwall, by sheared and brecciated rocks in the footwall. Thin sections of the scaly argillite indicates that grain-scale deformation is absent or poorly developed at this contact, suggesting that deformation may have occurred at relatively high hydrostatic pressures. Tectonic slivers of the siltstone, shale, and sandstone unit of the overlap sequence are locally incorporated in the fault. These slivers, coupled with varying stratigraphic sections adjacent to the contact in the footwall and hanging wall units, show that the contact is a fault. Nonetheless, bedding in rocks above and below the fault generally are concordant with the fault. In the few significant outcrops of hanging wall rocks (Golconda allochthon) examined, strata dip consistently eastward and do not display folds or other evidence of contractional deformation.

Available age data indicate that strata in the footwall are at least as young as Late Pennsylvanian (late Missourian), whereas strata in the hanging wall are no older than Late Pennsylvanian (late Missourian or early Virgilian) (table 1). These relations allow two possibilities. The first possibility is that the fault is a thrust fault that duplicates Upper Pennsylvanian strata, placing basinal strata onto shelfal strata. This interpretation would require that the fault is essentially a footwall flat that outside our study area has ramped upward from a position below Upper Pennsylvanian strata. This hypothesis implies that shortening was significant because the fault places basinal facies onto shelfal facies. A thrust model could be confirmed if Permian strata are eventually found to be present in the undated uppermost part of the siltstone, shale and sandstone unit in the footwall of the fault. The second possibility is that the fault is fundamentally a depositional contact modified by small displacement faults that may be of extensional character. In this case, small displacement faults form a zone of stratal disruption in Upper Pennsylvanian strata, perhaps in an interval of incompetent shale. This hypothesis requires the rocks of the overlap sequence and the Golconda allochthon at one time formed a continuous depositional succession that recorded basin subsidence in the late Paleozoic. This hypothesis satisfies our present observations and data, but it is not supported by regional relations of the Golconda allochthon, which exhibits older-on-younger relations indicative of contractional deformation (for example, Miller and others, 1982). Our studies to date cannot distinguish between these two possibilities. Continuing paleontological analysis of footwall and hangingwall rocks coupled with structural studies may help resolve this question.

High-angle faults

Ubiquitous high-angle normal faults in the north-central part of The Cedars quadrangle greatly complicate its geology. Most high-angle faults are small displacement, north-trending structures. The most significant of these are portrayed in figure 2 and include range-bounding west-dipping structures along the western Shoshone Range as well the north-striking fault that marks the eastern extent of the Golconda allochthon in the interior of Cedars quadrangle. Using the basal contact of the overlap sequence as a datum, the latter fault drops rocks down to the west a minimum of 300 m, whereas the distribution of Tertiary volcanic rocks suggest a minimum displacement of about 500 m, assuming they were once present east of the fault as well as to the west. These faults truncate the Tertiary volcanic rocks, indicating that they were active in post-Oligocene time.

Not shown in figure 2 are numerous very small displacement brittle faults that appear to be related to the more

Figure 11. Northward view of low-angle fault contact between argillite and siltstone unit of Golconda allochthon and siltstone, shale, and sandstone unit of overlap sequence. Contact is marked by dark, scaly shale.

prominent north-striking faults and cause much of the structural complexity in the north-central part of the quadrangle. These faults commonly are difficult to locate in the field because of poor exposure, superimposed alteration, and because they commonly juxtapose similar rocks. Marker beds, however, for example the basal unconformity of the overlap sequence, indicate that incremental amounts of down-to-the-west displacement has resulted in more than 500 m of cumulative displacement on these faults (fig. 12). These relations show that the Battle Formation, a common host rock in the Battle Mountain Mining District, is significantly thinner than is apparent from the map pattern shown in figure 2*A*.

A second set of widely spaced high angle normal faults intersects the north-striking faults in the north-central part of the quadrangle (fig. 2). These faults are east-striking and appear to control positions of some major canyons. Over 200 m of displacement can be demonstrated on these faults, although they have an inconsistent sense of displacement. The southernmost faults of this type in the north-central part of The Cedars quadrangle form a trough that drops the siltstone, shale, and sandstone unit down against the conglomerate and siltstone unit. The northernmost east-striking faults may form the southern margin of a second east-striking trough whose axis lies to the north. These structural troughs seem to be part of a large, east-striking extensional depression in the central Shoshone Range defined by the distribution of the Caetano Tuff (Stewart and Carlson, 1976; Stewart and McKee, 1977).

The relative ages of the north and east-striking fault systems are presently unclear. Map patterns suggest that the north-striking faults displace the east-striking ones and thus are younger, although alternatively both systems may have developed concurrently.

ALTERATION

A zone of alteration is present in the north-central part of The Cedars quadrangle, along the western margin of the Shoshone Range (fig. 2). Host rocks of the alteration are the conglomerate and siltstone unit of the overlap sequence. The alteration is characterized by widespread silicification that is coupled with local development of wispy, red halos marking sites of oxidized disseminated pyrite (fig. 13). Workings excavated for mercury are present in the most intense areas of alteration and the large number of recent prospect pits indicate that gold exploration also has been focused on this zone. The alteration is concentrated along north-striking zones that are most likely controlled by the north-striking faults discussed above. Alteration appears to diminish eastward in the conglomerate and siltstone unit, does not affect the overlying siltstone, shale, and sandstone unit of the overlap sequence, and only locally affects the rocks of the Golconda allochthon. No igneous rocks have been found to be associated with the altered rocks.

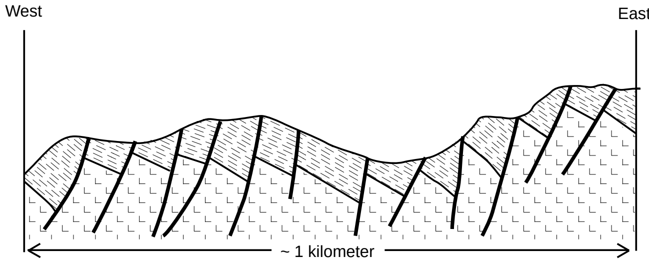

Figure 12. Conceptual structural section illustrating the apparent paradox of eastward bedding attitudes and westward regional dip. Numerous west-dipping normal faults drop section down to the west in incremental fashion. Poor exposure, massive lithologic units, and alteration obscure normal faults in the field so that stratigraphic section appears to be homoclinal and substantially thicker than actual stratigraphic thickness.

REGIONAL CORRELATION OF THE OVERLAP SEQUENCE

Two units are recognized in the overlap sequence in the area of figure 2*A*: (**1**) an undated lower unit of conglomerate and siltstone and (**2**) an upper unit of siltstone, shale, and sandstone that contains a sandy limestone with Late Pennsylvanian (Missourian) conodonts and reworked Osagean and Atokan conodonts. These strata form a marine sequence deposited on deformed strata of the Roberts Mountains allochthon.

The “classic” Antler overlap sequence of Roberts (1964) is present in the Battle Mountain area to the north of The Cedars quadrangle (fig. 1). From oldest to youngest, the overlap sequence in the Battle Mountain area includes the Middle Pennsylvanian (Atokan, Desmoinesian?) Battle Formation, Pennsylvanian and Permian Antler Peak Limestone, and Permian Edna Mountain Formation (fig. 14). The Battle Formation and limestone units correlative with the Antler Peak Limestone have been mapped as far north as the Osgood Mountains (e. g. Saller, 1980) (fig. 1).

From the northern Shoshone Range north to the Osgood Mountains, deposition on the Antler orogenic highlands occurred during regional subsidence in the Pennsylvanian and early Permian (Roberts, 1964; Saller, 1980; Madrid, 1987; Miller and others, 1992). Topographic irregularities are reflected in the wide variability in thickness of the Battle Formation: 240 m thick at Battle Mountain; 40 to 130 m thick in the Osgood Mountains (Saller, 1980), 30 to 200 m thick in the northern Shoshone Range (Madrid, 1987), suggesting that sandstone and conglomerate of the Battle Formation accumulated in valleys of the foundering highlands. Saller (1980) described a transgressive sequence of environments and lithofacies within the Battle Formation beginning with conglomeratic proximal braided stream deposits and culminating with calcareous sandstone, mudstone, and conglomerate of tidal and deltaic origin. In the northern Shoshone Range, the sequence consists of undated fluvial strata and interbedded talus deposits that transition upward to marine strata (limestone) with conodonts having a possible range from Middle Pennsylvanian to Early Permian (Madrid, 1987).

The conglomerate and siltstone unit in The Cedars quadrangle is likely coeval with the Battle Formation in its type area. It has not been dated directly but is depositionally overlain by Missourian strata. We interpret the unit as a marine turbidite sequence whose coarse-grained detritus may have been carried to the shores of the Antler highlands by high energy fluvial systems similar to those which deposited non-marine strata of the type Battle Formation. These gravels were subsequently redeposited into an extensional marine basin, possibly in a fan-delta along a faulted margin. The submarine basement of the Antler islands and, possibly, the easternmost margin of the Havallah depositional basin must have been composed of deformed strata of the Roberts Mountains allochthon.

The conglomerate and siltstone unit consists of thick, coarse-grained poorly-sorted clastic deposits that may represent a transitional facies between nonmarine deposits of the classic Battle Formation and clastic marine units in the Havallah basin, which was located to the west prior to thrusting. Coeval units in the Havallah basin consist of submarine conglomeratic debris flows with clasts of Devonian and older radiolarian chert that were deposited above latest Devonian (locally) and Mississippian pillow basalt and pelagic radiolarian chert (Murchey, 1990). Alternatively, the conglomerate and siltstone unit may represent an eastward transition from the Battle Formation to coeval and (or) older Mississipian and Lower Pennsylvanian marine conglomerate and quartzite (e.g., the Diamond Peak Formation in eastern Nevada) that were deposited in the foreland of the Antler orogenic belt.

Shallow seas transgressed most of the Antler highlands by the Late Pennsylvanian, creating a variety of shallow marine environments favorable for the deposition of the Missourian or Virgilian to Wolfcampian Antler Peak Limestone and the Atokan to Wolfcampian Etchart Limestone (Saller, 1980). In the north-central part of The Cedars quadrangle, the lower part of the siltstone, shale, and sandstone unit contains a thin interval of limestone that yields conodonts as young as Missourian. These data indicate that this part of the siltstone, shale, and sandstone unit is coeval with at least part of the Antler Peak Limestone. The siltstone, shale, and sandstone unit displays sedimentary structures that indicate deposition above wave base. The upper part of the siltstone, shale, and sandstone unit above the limestone-bearing interval is undated but is lithologically similar to the early Guadalupian Edna Mountain Formation and thus may include Permian strata.

As previously mentioned, map locality 3 in the sandy limestone of the siltstone, shale, and sandstone unit contains a conodont fauna with Missourian conodonts and older reworked Atokan and Osagean conodonts. The Atokan conodonts were reworked from marine strata coeval with parts of the Battle

Figure 13. Photograph of liesegang banding in alteration zone near small, abandoned mercury mine. Alteration developed in siltstone of conglomerate and siltstone unit of overlap sequence.

Formation, Highway Limestone, and the Etchart Limestone. The presence of the middle Osagean reworked conodonts is intriguing because Mississippian strata are not preserved in the classic Antler sequence. The conodonts indicate that Osagean marine strata were deposited locally in the Antler highlands and subsequently eroded, or that Early Mississippian conodonts from the foreland or shelf region to the east were transported westward to the site of the former Antler orogenic belt, probably in the Pennsylvanian.

REGIONAL CORRELATION OF THE GOLCONDA ALLOCHTHON

The argillite and siltstone unit of figure 2*A*, and the more siliceous and partly older chert and argillite unit to the south in figure 2*B*, are generally similar in age, lithology, and faunal assemblages to the structurally lowest, thrust-bounded lithotectonic units of the Havallah sequence lying along the eastern edge of the Golconda allochthon in the Battle Mountain area, southernmost Shoshone Range, and the northern Toiyabe Range (Murchey, 1990; Tomlinson, 1990) (lithostratigraphic unit 1, figs. 14 and 15). All of these exposures of the Havallah sequence are dominated by hemipelagic strata (argillite, siltstone, mudstone) deposited in a relatively deep marine environment. Structurally higher lithotectonic units of the Golconda allochthon are characterized by less argillite, more bedded chert, pillow basalt, and in some structural units, a higher proportion of turbidite and debris-flow sequences (Stewart and others, 1986; Murchey, 1990; Tomlinson, 1990).

The argillite and siltstone unit undoubtedly was deposited in a relatively deep, hemipelagic setting similar to that of the Havallah strata, which elsewhere are demonstrably allochthonous. We insert a word of caution, however, regarding the correlation of the low-angle fault separating the argillite and siltstone unit from the underlying units of the overlap sequence in The Cedars quadrangle with the Golconda thrust fault. We have not proven an older-over-younger relation between these units, nor eastward vergence on the fault. It remains possible that the fault is an extensional fault and(or) that the Pennsylvanian overlap sequence (fig. 2*A*) foundered and was subsequently covered by deeper marine hemipelagic facies of the argillite and siltstone unit. If so, the “real” Golconda thrust may be present at a structurally higher position in The Cedars quadrangle. One possibility is that it lies beneath the more siliceous chert and argillite unit in the southern part of the quadrangle, which our age data indicates predates part of the overlap sequence. If so, the siltstone and argillite unit might lie in the footwall of the Golconda thrust as a preserved, autochthonous part of the Havallah basin, a relation not previously observed in north-central Nevada.

Figure 15 is a schematic north-south cross section of the Golconda allochthon showing inferred age, lithologic, and structural relations along the Golconda thrust from the Osgood Mountains to the southern Shoshone Range and northern Toiyabe Range along the Battle Mountain-Eureka trend. This

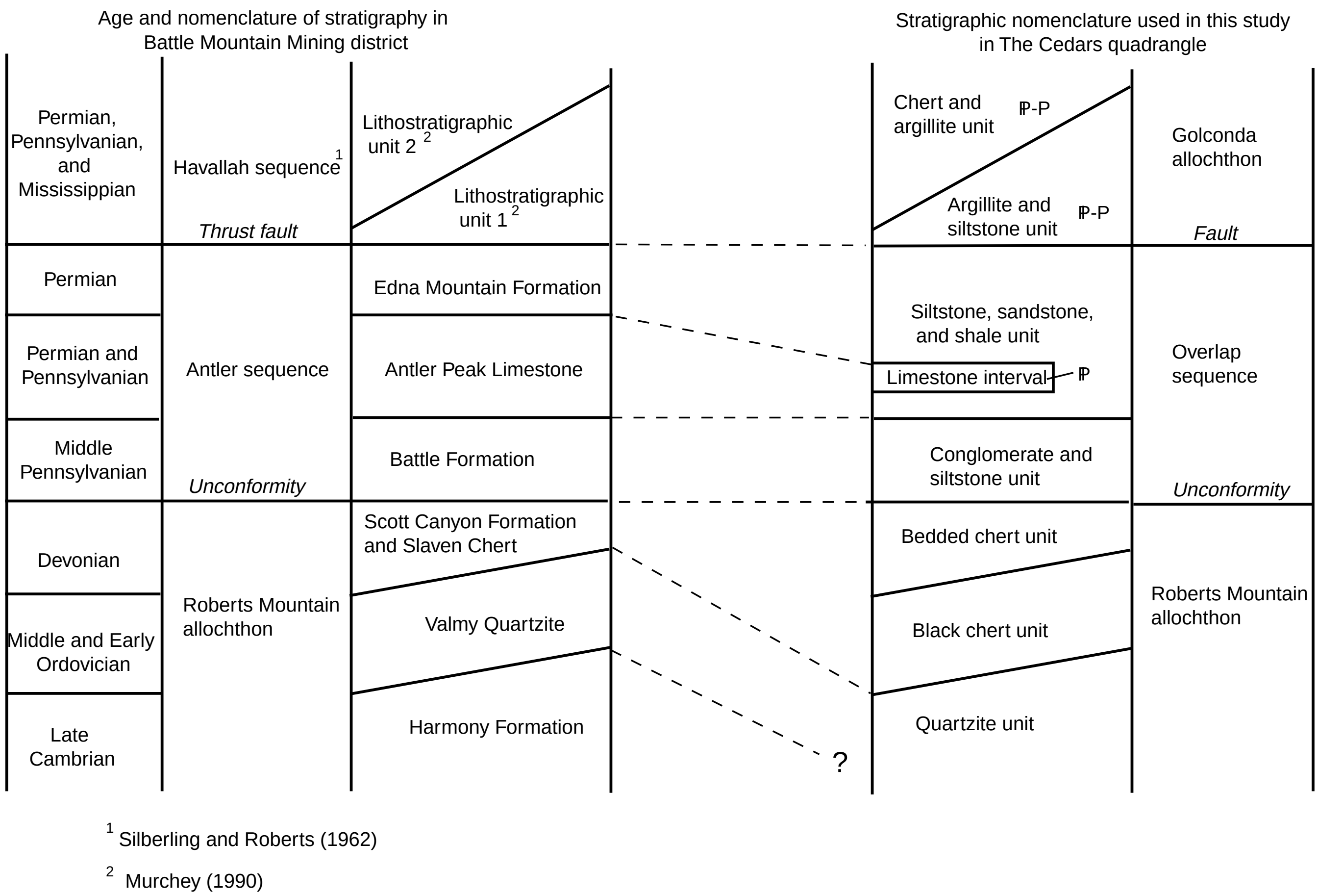

Figure 14. Proposed stratigraphic correlation, shown with dashed lines, rocks in The Cedars quadrangle with rocks in the Battle Mountain area. Solid diagonal lines indicate structural contacts between units. Ages and stratigraphy of Battle Mountain area from Doebrich and Theodore (1996).

diagram, modified from Tomlinson's (1990) schematic east-west cross section, illustrates that more distal, basinal parts of the Havallah basin lie above the Golconda thrust in the north, whereas more proximal parts of the basin lie above the thrust to the south. This relation suggests that the Battle Mountain-Eureka trend crosses the structural strike of the Golconda allochthon.

IMPLICATIONS TO MINERALIZATION

The Cedars quadrangle is located about 20 km west of the main axis of the Battle Mountain-Eureka trend, in about the same position in relation to that trend as the Cove and McCoy deposits (Shawe, 1991). The deposits of the Battle Mountain Mining District and associated deposits form the northern end of the Battle Mountain-Eureka trend and delineate a subtrend that extends southward over 100 km from the Getchell and Twin Creeks deposits to the Cove and McCoy deposits (fig. 1). Location of The Cedars quadrangle adjacent to the Battle Mountain Eureka-trend and on the southward projection of the deposits of the Battle Mountain area suggests that the quadrangle may be prospective for gold deposits that are pluton-related.

Doebrich and Theodore (1996) presented a model for gold mineralization in the Battle Mountain district and identified several characteristics that are common denominators to its major deposits. These are: (**1**) intersection of regional structural features such as faults; (**2**) presence of pre-late Eocene north-striking normal faults; (**3**) the presence of late Eocene or early Oligocene magmatically related hydrothermal systems; (**4**) the presence of rocks of the Antler sequence as a receptive host, and (**5**) the presence of the Golconda thrust, which acted as a seal for hydrothermal fluid flow.

Our initial stratigraphic and structural framework studies suggest that many of these common denominators also are present in The Cedars quadrangle. The stratigraphic relations in the quadrangle compare favorably with those in the Battle Mountain area in that correlatives of the Antler sequence are present and are sufficiently thick and coarse-grained to provide

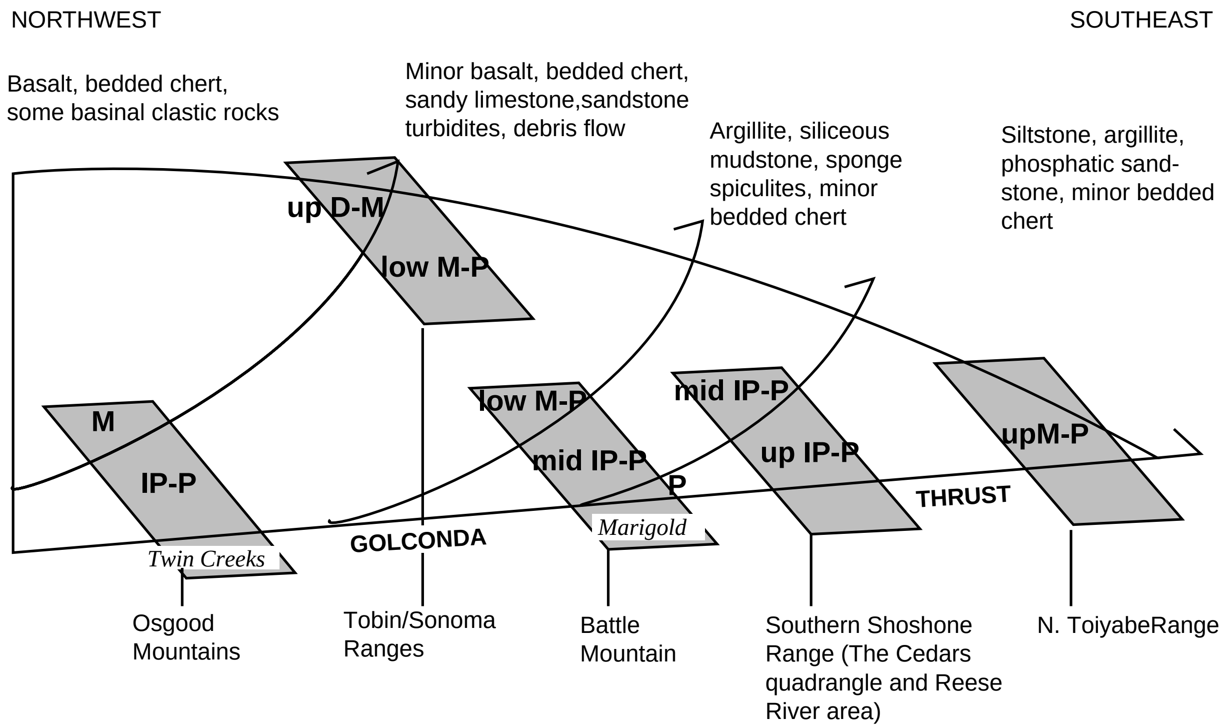

Figure 15. Conceptual model for the Golconda allochthon along a profile along Battle Mountain-Eureka trend (fig. 1) from the Osgood Mountains to the northern Toiyabe Range. Diagram illustrates relative structural positions and ages (Devonian to Permian) of major lithostratigraphic units of the Golconda allochthon. No attempt has been made to illustrate internal structural complexities within individual lithostratigraphic units. The structural position of the Twin Creeks and Marigold deposits are shown for reference.

a receptive host for subsequent hydrothermal ore deposition. Widespread alteration is present in these rocks in The Cedars quadrangle. Thin-bedded and fine-grained rocks similar to those of the Golconda allochthon overlie the Antler sequence on a low-angle structural contact analogous to the Golconda thrust. The restriction of hydrothermal alteration to coarse-grained rocks below this low-angle fault, despite our uncertainty about its correlation, indicates that it may have played a role similar to that of the Golconda thrust in controlling the channeling and ponding of ascending hydrothermal fluids. Our identification of north-striking and east-striking faults in The Cedars quadrangle allows the possibility that mineralization may be present in the areas where these faults intersect. Alteration zones are visibly related to north-striking faults, indicating that hydrothermal fluid flow was structurally controlled. The absence of outcrops of intrusive rocks associated with the hydrothermal system and the silica + pyrite alteration products prevent confirmation of a magmatic origin for the system but it may reasonably be hypothesized to have originated from a magmatic body at depth. At present, we do not know the precise age of the hydrothermal system nor the age of the structural zones that controlled its distribution, but both are likely of Tertiary age.

The presence of hydrothermal alteration in The Cedars quadrangle without associated magmatic rocks suggests that sediment-hosted Carlin-type gold occurrences also must be considered. Although The Cedars quadrangle is located to the west of the Carlin trend, Carlin-type deposits are located at the Pipeline and Cortez deposits about 30 km to the northeast of The Cedars quadrangle and at the Getchell and Twin Creeks deposits, about 75 km north of Battle Mountain. The Pipeline and Cortez deposits are located in carbonate rocks in the footwall of the Roberts Mountains allochthon, a relation not exposed in The Cedars quadrangle. Rytuba (1985), however, suggested that the heat that drove hydrothermal systems at the Cortez and nearby deposits was provided by the waning stage of the magmatic system that produced the Caetano Tuff. The source of the heat that produced the hydrothermal alteration in The Cedars quadrangle is unknown, but could have been related to the Caetano Tuff magmatic system through a hydrothermal system developed in the east-striking extensional trough. The Twin Creek and Getchel deposits are structurally controlled deposits hosted in part by rocks of the Roberts Mountains allochthon and carbonate rocks of the overlap sequence that unconformably overlie the Roberts Mountains allochthon. The Twin Creeks and Getchell deposits are located about the same distance to the north of the porphyry-related and distal disseminated silver-gold deposits in the Battle

Mountain Mining District as The Cedars quadrangle is to the south of the Battle Mountain Mining District. This distribution suggests an alternative possibility that the hydrothermal systems that led to mineralization of the Carlin-type deposits at Twin Creeks and Getchell could be mineralized systems distal to magmatic centers in the Battle Mountain Mining District (T. G. Theodore, oral comm., 1997). This model suggests that Carlin-type deposits analogous to those at Twin Creeks and Getchell also might be possible in The Cedars quadrangle.

CONCLUSION

Initial results in The Cedars quadrangle show that the Paleozoic rocks of the area can be divided into three major lithostratigraphic units: the Roberts Mountains allochthon, overlap sequence, and Golconda allochthon. The Roberts Mountains allochthon consists of contractionally deformed black chert, bedded chert, and fine-grained quartzite. The age of these units has not been established in The Cedars quadrangle but probably is correlative with the Ordovician Valmy Formation and the Devonian Slaven Chert or Devonian Scott Canyon Formation.

In The Cedars quadrangle, the overlap sequence consists of two parts, in aggregate measuring about 400 m in thickness. The lower part consists of interbedded chert-pebble conglomerate and thin-bedded siltstone that comprise sedimentary-gravity flows including turbidites. These rocks appear to be correlative with the Battle Formation in the Battle Mountain area. The upper part of the overlap sequence consists of heavily bioturbated thin-bedded siltstone, shale, and sandstone, which near its base includes a thin interval of interbedded calcareous sandstone and sandy limestone. The limestone has yielded Late Pennsylvanian conodonts that indicate it may be correlative with at least part of the Antler Peak Limestone of the Battle Mountain area. The remainder of the upper part of the overlap sequence in The Cedars quadrangle displays lithologic affinities to the Permian Edna Mountain Formation of the Battle Mountain area, although we have not recovered any fossils that might confirm this correlation. The entire overlap succession appears to compose a shoaling sequence that progressed from deposition of turbidites at the base to shelfal clastics and limestone at the top. The marine character of the overlap sequence in The Cedars quadrangle suggests that it may have been deposited in a location more basinward than the dominantly fluvial and shallow-marine overlap sequence deposits in the Battle Mountain area. Considering the thickness of the Battle Formation and its correlatives (generally < 300 m), the preponderance of fluvial deposits, and the extensional tectonic environment of its deposition (Saller, 1980; Miller and others, 1992), we suggest that the overlap sequence may comprise fan-delta deposits that prograded southwestward from the Antler highlands.

Overlying the overlap sequence in The Cedars quadrangle is the Golconda allochthon, whose rocks are assigned to the Havallah sequence of Murchey (1990) and which contains two distinct lithologic assemblages. The northern assemblage consists of thin-bedded siltstone and argillite that yields Late Pennsylvanian conodonts and Permian radiolarian faunas, whereas the southern assemblage consists of argillite and chert that yield Middle Pennsylvanian to Permian radiolarian assemblages. Both lithologic assemblages are most similar to hemipelagic deposits that are the most proximal of the structural-stratigraphic packages recognized by Murchey (1990) in the Golconda allochthon. We suggest that both lithologic assemblages of the Havallah in The Cedars quadrangle were probably deposited along the eastern margin of the Havallah basin and now comprise some of the structurally lowest rocks of the Golconda allochthon.

Separating the overlap sequence and the Golconda allochthon in The Cedars quadrangle is a low-angle fault that is located at the position of the Golconda thrust in the Battle Mountain area. Our paleontologic data and structural observations, however, at present do not confirm older-on-younger relations on this fault. Instead, the fault could represent a zone of stratal disruption in an otherwise homoclinal sequence. The stratal disruption could have been caused by extensional deformation, perhaps by submarine landsliding in the Permian. Alternatively, it is possible that the undated siltstone, shale, and sandstone unit in the upper part of the overlap sequence may prove to contain Permian fossils, thus requiring a thrust relation along the low-angle fault. A third possibility is that the Golconda thrust may be located at the contact between the siliceous, southern lithologic assemblage of the Havallah sequence in The Cedars quadrangle and the siltstone and argillite of the northern assemblage of the Havallah. This relation would require that the most proximal part of the Havallah basin (i.e., the siltstone and argillite unit) be present in the footwall of the Golconda thrust, a relation that has not been previously recognized.

Our studies in The Cedars quadrangle provide an opportunity to test and refine the model developed by Doebrich and Theodore (1996) for ore genesis in the Battle Mountain Mining District. They suggested that fluids emanating from porphyritic intrusions resulted in the distal disseminated silver-gold mineralization both near the magmatic bodies and in adjacent or structurally higher areas that lack magmatic bodies. The Cedars quadrangle contains most of the elements critical for ore deposition, including (**1**) the chemically receptive Antler sequence, (**2**) an overlying low-angle fault, and (**3**) hydrothermal alteration possibly related to a buried magmatic system at the intersection of generally north and east-striking high-angle fault systems. These findings suggest that the conditions suitable for distal disseminated silver-gold occurrences are present in The Cedars quadrangle.

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