Text and references for Nevada Bureau of Mines and Geology Map 143

GEOLOGIC MAP OF THE BEAVER PEAK QUADRANGLE

ELKO and EUREKA COUNTIES, NEVADA

by

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INTRODUCTION

Regional geologic studies in the Beaver Peak (BP) Quadrangle (fig. 1) near the northern end of the Carlin trend of gold deposits have shown that rocks of the Late Pennsylvanian and Permian Strathearn Formation are fairly widespread in the map area. The Strathearn Formation in the quadrangle stratigraphically and temporally brackets emplacement of a major allochthonous thrust plate of mainly quartzarenite of the Ordovician Vinini Formation (Theodore and others, 1998; 2000a). This relation has profound implications concerning a previously undocumented late Paleozoic contractional tectonism in the region.

Geologic mapping in the Tuscarora Mountains forms part of wide-ranging investigations in northeast Nevada supported by the Western Region Gold Project of the U.S. Geological Survey (USGS), and the investigation is directly supportive of ongoing mineral-assessment tasks and regional geologic and geochemical studies in the Humboldt River Drainage Basin Project of the USGS, also currently (2003) underway. The primary objective of these studies is to advance understanding of the genesis of gold deposits in the region in order that state-of-the-art mineral assessments might be prepared upon request by other Federal agencies such as the U.S. Bureau of Land Management. The northern Carlin trend of gold deposits, which is inferred to have contained as much as 150 million ounces of gold prior to the startup of major mining operations in the early 1960s, passes just to the southwest of the southwest corner of the BP Quadrangle (Bettles 2002; Moore, 2002).

The BP Quadrangle is in the Tuscarora Mountains, Nevada, between north latitudes 41°00′00″ and 41°07′30″ and west longitudes 116°15′00″ and 116°22′30″. Primary access to the quadrangle is either (1) from Maggie Creek to the southeast, using the Little Jack Creek drainage, where a haul road leads to the abandoned Coyote bedded barite mine (Papke, 1984), or (2) from Squaw Creek, near the northwest corner of the quadrangle, where a jeep trail leads to a number of ridgelines in the northern half of the map area. All roads and trails in the area are not maintained, and some gates near active mining operations near the southwest corner of the quadrangle may, at times, be locked.

Previous investigations in the BP Quadrangle include the regional Elko County geologic map (Coats, 1987), and geologic mapping studies by numerous mining companies. In addition, small areas of the quadrangle are included in the theses by Ettner (1989) and Foulk (1991), and the geology of the area is summarized in papers by Berger and others (2001), and Theodore and others (1998, 2000a, 2000b, 2003).

GEOLOGIC FRAMEWORK OF THE BEAVER PEAK AREA, TUSCARORA MOUNTAINS

Recent geologic investigations in the BP area—undertaken as part of a comprehensive geologic and geochemical study of the west-adjoining Santa Renia Fields (SRF) Quadrangle and the BP Quadrangle—have established the presence of a remarkably intact lower Paleozoic stratigraphic sequence of siliceous rocks in the upper plate of the Roberts Mountains thrust (RMT) (Theodore and others, 1998, 2000a). The allochthon of the RMT in this area also contains a number of well-exposed relations of upper plate units with the Strathearn Formation of the overlap assemblage (Roberts, 1964). The RMT initially was emplaced during the middle Paleozoic Antler orogeny (see also, Roberts and others, 1958; Sandberg and others, 1982; Saucier, 1997; Cluer, 1999; Trexler and Giles, 2000). Prior to herein described investigations in the Tuscarora Mountains, (1) the Antler orogeny was envisaged as having been completed by the Late Pennsylvanian; that is, prior to deposition of the Pennsylvanian and Permian Antler Peak Limestone (Roberts and others, 1958; Roberts, 1964; Dickinson, 2001), and (2)

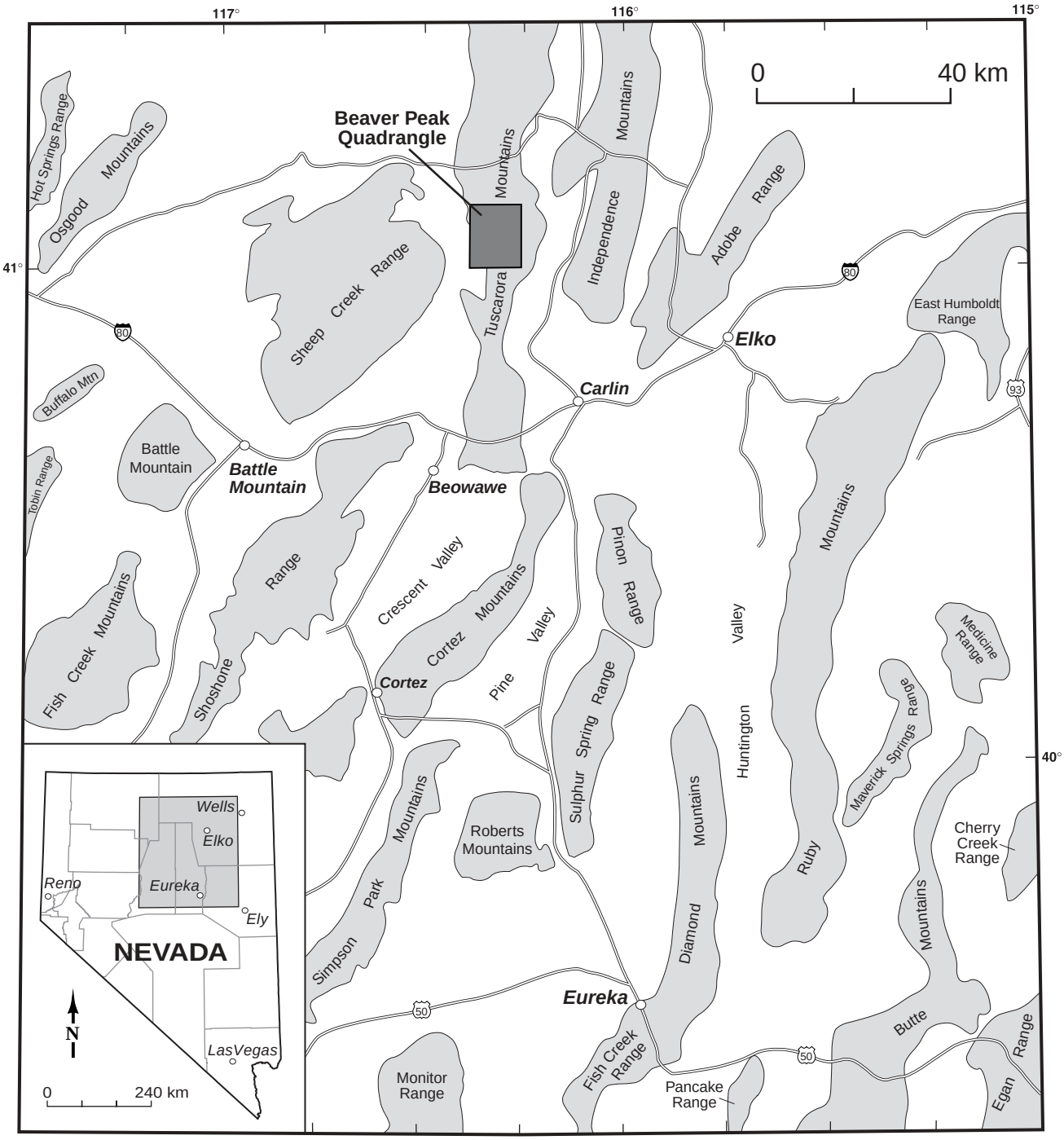

Figure 1. Location map of north-central Nevada.

the next succeeding contractional tectonism to affect the Antler orogen is inferred to have been the Late Permian and/or Early Triassic Sonoma orogeny (Silberling and Roberts, 1962). However, our investigations in the Tuscarora Mountains and in the Shoshone Range (J.K. Cluer, written commun., 2000; see also Cluer and others, 1997) strongly suggest that during the middle Late Pennsylvanian to middle Early Permian a regional east- to southeast-directed thrusting event reactivated significant parts of the RMT allochthon. The Lander thrust in the Shoshone Range is envisaged by Cluer to have a formed a duplex with the middle Paleozoic RMT, and the Coyote thrust in the BP Quadrangle is (1) geometrically equivalent of the Lander thrust, and (2) probably represents a late Paleozoic reactivation along a duplex thrust formed at the same time as initial emplacement of the upper plate of the RMT in the Tuscarora Mountains.

Previously, late Paleozoic deformation of the Antler orogen has been referred to as the Humboldt orogeny (Ketner, 1977), and the Humboldt orogeny was mainly envisioned as including late Paleozoic epeirogenic uplift, as well as depression of a number of basins widespread throughout the Cordillera (Snyder and others, 2000). Both uplift and depression owe their origins primarily to development of the Ancestral Rockies (Dickinson, 2001). Regardless, well-documented shortening recognized in the BP Quadrangle involving the Strathearn Formation requires significant modification of earlier concepts of regional tectonism in this part of the Great Basin (see also Cashman and others, 2000, 2001). The Strathearn Formation is equivalent in age to the upper parts of the Pennsylvanian and Permian Oquirrh Group in west-central Utah (Roberts and others, 1965), as well as the Pennsylvanian and Permian Antler Peak Limestone of the overlap assemblage at Battle Mountain, Nevada (Roberts, 1964).

The BP area includes siliceous rocks belonging to many of the formations that make up the upper plate of the RMT in the region. The lower plate of the RMT crops out near the Capstone-Bootstrap and Tara gold mines as well as in and near the open pit of the Dee gold mine approximately 10 km west of the quadrangle (Moore, 2002). As pointed out by Saucier (1997), largely carbonate rocks of the lower plate of the RMT regionally are cut in a number of places by thrust faults and also folded probably during the Antler orogeny, thereby indicating that some lower plate rocks are themselves allochthonous (see also Dewitt, 2001). The widely exposed siliceous package of rocks in the upper plate of the RMT in the quadrangle includes Upper Ordovician Vinini Formation of Merriam and Anderson (1942; see also Finney and Perry, 1991; Finney and others, 2000), Silurian and Devonian Elder Sandstone of Gilluly and Gates (1965), and Devonian Slaven Chert of Gilluly and Gates (1965). The Slaven Chert includes a widespread chert mélange unit. The Vinini Formation, Elder Sandstone, and Slaven Chert all are well exposed south of BP where stratigraphic relations among the formations have been revealed by sharply incised deep canyons near the southeast corner of the quadrangle. As mapped in this part of the Tuscarora Mountains, strata of the three formations are remarkably devoid of altered basaltic rock (greenstone), a fact previously noted as well by Dubé (1987, 1988) in the Lake Mountain area of the Roberts Mountains allochthon approximately 10 km northeast of BP. Uppermost strata of the Elder Sandstone regionally are as young as early Early Devonian (Noble, 2000). The Elder Sandstone at its base locally contains discontinuous, approximately 10-m-thick sequences of well-bedded knobby black and blue-green chert that probably correlate with the Cherry Spring chert unit of Noble and others (1997), a unit exposed in the Adobe Range, approximately 50 km to the east.

Siliceous upper plate rocks of the RMT are overlain unconformably—locally in several places with an angular discordance of about 30º—by a variety of rocks belonging to the middle Late Pennsylvanian and middle Early Permian Strathearn Formation, which comprises the overlap assemblage of the Antler orogen in the area. Some of the apparent map discrepancies between bedding attitudes in the Strathearn Formation and the basal contact of the Strathearn Formation are the result of significant paleotopography present in the area at the time of development of the Strathearn basin. Further, such paleotopography also is manifest by the disjointed nature of the areas of outcrop of the Strathearn Formation in the quadrangle. The regional extent of the Strathearn Formation recently has been broadened into the area from its type section in Carlin Canyon (Dott, 1955; Cashman and others, 2000, 2001) approximately 20 km to the southeast. However, the rocks of the Strathearn Formation in the greater BP area (fig. 2), on the basis of a number of well-constrained conodont and fuslinid biostratigraphic determinations (Theodore and others, 1998; see also table 1), are equivalent in age to the lower unit (Cashman and others, 2001) of the Strathearn Formation at Carlin Canyon. In addition, the Strathearn Formation also crops out extensively in the Snake Mountains approximately 100 km to the northeast where its undeformed basal strata rest unconformably on deformed sequences of rock in the upper plate of the RMT (McFarlane, 1997).

Structural relations of the Strathearn Formation in the area have wide-reaching tectonic implications. Locally, basal strata of the Strathearn Formation—in places commonly chert-pebble conglomerate—are middle Late Pennsylvanian in age, whereas in other places the Strathearn displays dolomitic siltstone strata at its base that may be as young as middle Early Permian. Rocks assigned to the Strathearn in the northwest quadrant of the quadrangle mostly are siliceous chert-pebble conglomerates. Overall map distributions of the formation primarily are the result of its deposition on a highly irregular paleotopographic surface. However, prominent sequences of a second chert- and quartzarenite-pebble conglomerate also comprise a number of the stratigraphically highest outcrops in the overall stratigraphic succession of the Strathearn Formation (Theodore and others, 2003). The map distributions and traces of two representative sections—a western section and a Beaver Peak section—through the two conglomerate units are

shown on figure 2. Composited stratigraphic relations of these two conglomerate units (fig. 3) indicate that the upper conglomerate prominently exposed in the western section belongs near the top of the Strathearn, whereas the sequence at BP includes the lower conglomerate as well as a prominent overlying sequence of dolomitic siltstone (fig. 3). The upper conglomerate is not present at BP.

The Strathearn Formation in the quadrangle includes geologic relations with rocks in the upper plate of the RMT that are crucial to regional tectonic syntheses, and the formation is age-equivalent to a number of other predominantly clastic formations in the region. As described above, the chert- and quartzarenite-pebble conglomerate in the western section is well exposed on a high ridge approximately 3 km southwest of BP (Berger and others, 2001)—this ridge as well as BP itself were referred to previously as the Dalton Peaks by the Clarence King-led 40th Parallel Surveys (Emmons, 1877). The ridge southwest of BP also is referred to informally as Coyote ridge (Steve Moore, oral commun., 2001). The Strathearn Formation includes biofacies indicative of a marine depositional environment. Dubé (1987) previously assigned similar appearing rocks in the nearby Lake Mountain area to the Pennsylvanian and Permian Antler Peak Limestone, and rocks near the mouth of Coyote Creek, approximately 1.6 km east-northeast of the southeast corner of the BP Quadrangle, also belong to the Strathearn Formation (F.R. Hladky and P.R. Lewis, unpub. data, 2001).

Early Permian strata of the Strathearn Formation, mostly made up of the upper conglomerate, unequivocally

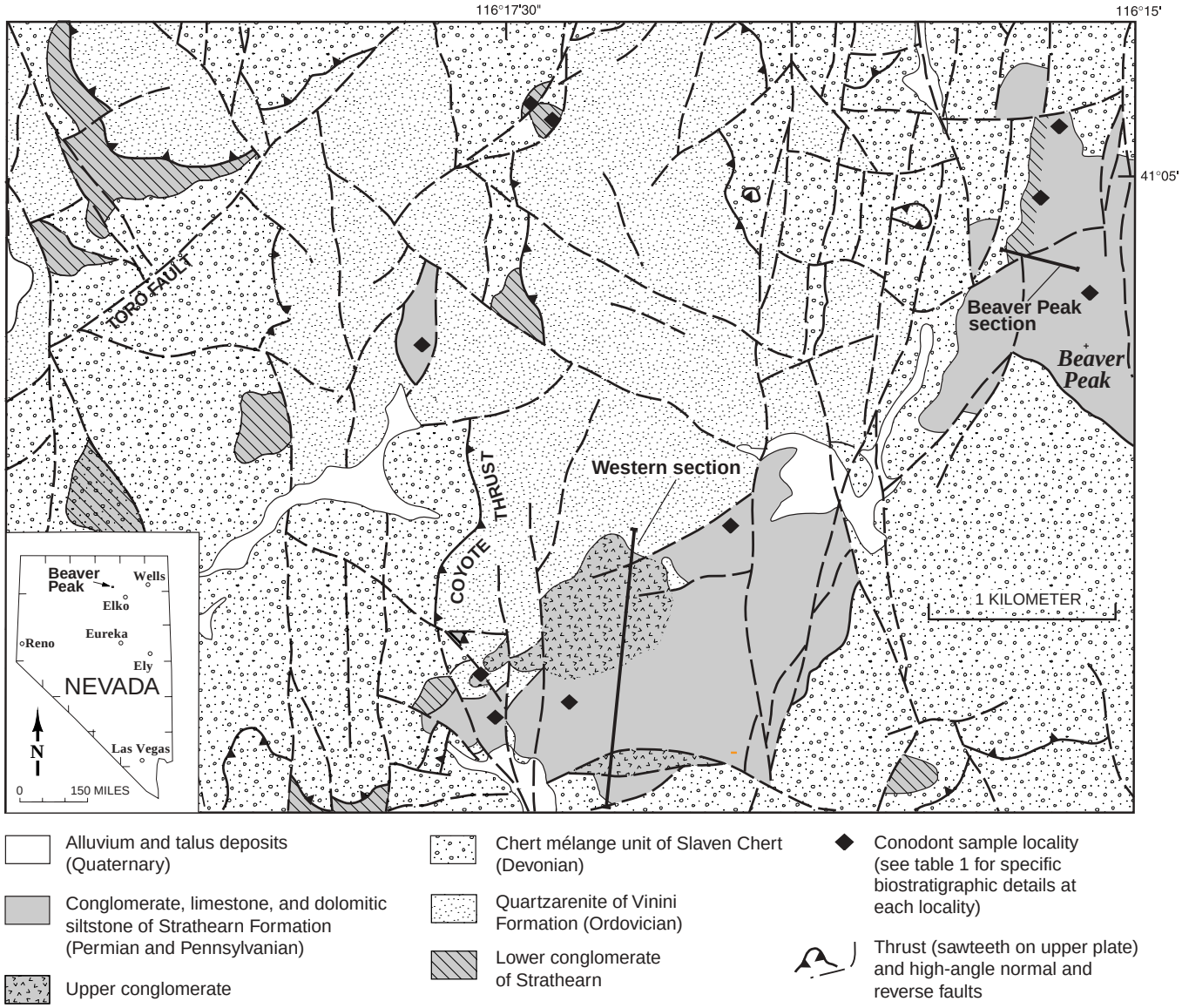

Figure 2. Map of the greater Beaver Peak area, Nevada, showing distribution of upper and lower conglomerates and conodont localities in Strathearn Formation. Modified from Berger and others (2001) and Theodore and others (2003).

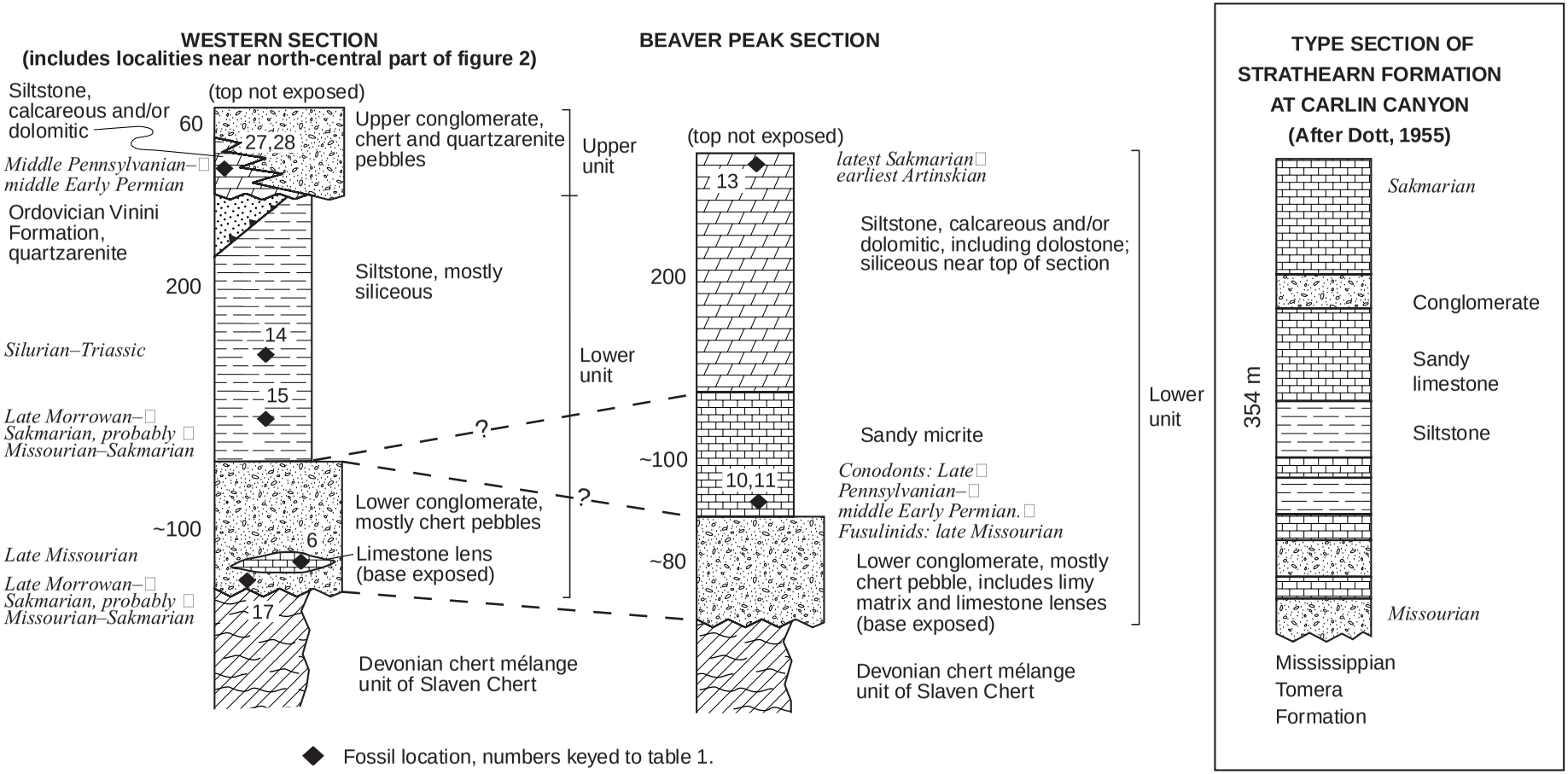

Figure 3. Schematic stratigraphic sections of Pennsylvanian and Permian Strathearn Formation in greater Beaver Peak area, Nevada, compared with type section of the Strathearn Formation at Carlin Canyon, Nevada. Thickness shown in meters. Locations of composite section lines shown on figure 2. Lower unit of Strathearn Formation near Beaver Peak section includes wedging out of sandy micrite and lower conglomerate so that siltstone unit, in places, is in direct contact with underlying chert mélange unit of Devonian Slaven Chert. Modified from Berger and others (2001).

Table 1. Description of selected conodont, graptolite, radiolarian, and fusulinid samples from the Beaver Peak and Rodeo Creek NE Quadrangles, Nevada.

[Conodont samples collected by T.G. Theodore; conodont analyses by A.G. Harris. Graptolite samples collected by S.C. Finney and C.L. Morris; graptolite analyses by S.C. Finney. Fusulinid samples collected by T.G. Theodore; analyzed by C.H. Stevens. Map locality numbers keyed to localities on geologic map.
CAI, conodont color alteration index; HMC heavy mineral concentrates]

CONODONTS

Map Loc. No. (Field No.; USGS Colln. No.)	Latitude N. Longitude W. 7.5 Min. Quadrangle	Stratigraphic Unit and Lithology	Conodont Fauna	Age	CAI	Conodont Biofacies and Depositional Environment	Sample Weight and Composition of Heavy-Mineral Concentrate (HMC)
6 (97TT-51; 33385-PC)	41°05'15" 116°17'25" Beaver Peak, Elko County	Strathearn Formation. Approximately 1-m-thick bed near base of chert-pebble conglomerate sequence resting on Devonian chert mélange unit of Slaven Chert. Thin section contains abundant fusulinids.	*Streptognathodus* sp. 10 Pa and 3 Pb elements (small juveniles, subadults, and a few adults) 19 indet. bar, blade, and platform fragments	Desmoinesian-Sakmarian (Late Pennsylvanian-early Early Permian); fusulinids from same locality indicate a late Missourian age (middle Late Pennsylvanian).	1.5-2	Indeterminate (too few generically identifiable conodonts); normal-marine depositional setting.	1.5 kg of rock processed (80 g +20 and 74 g 20-200 mesh insoluble residue). HMC: Chiefly anhedral and euhedral barite and lesser ferroan dolomite and composite ferruginous flakes.
7 (97TT-52)	41°05'11" 116°17'21" Beaver Peak, Elko County	Strathearn Formation. Buff-weathering dolomitic siltstone containing angular fragments of quartz and abundant K-feldspar.	1 indet. bar or blade fragment	Ordovician-Triassic.	1.5 or 2	Indeterminate (too few conodonts).	0.5 kg of rock processed (380 g +20 and 30 g 20–200 mesh HMC: insoluble residue). Composition not recorded.
8 (97TT-53; 11517-CO)	41°05'29" 116°21'46" Beaver Peak, Elko County	Vinini Formation. Gray-brown micrite. Approximately 1 m thick, interbedded with relatively thick siltstone sequence.	Virtually all conodonts are fragments of juveniles. *Amorphognathus* sp. indet. 2 Pa (small fragments), 1 Pb, 2 Sb, and 8 bar element fragments 7 *Panderodus* sp. indet. elements 1 S element *Paroistodus mutatus* (Rhodes)? *Periodon* sp. indet. 2 S element fragments 2 *Protopanderodus liripipus* Kennedy, Barnes, and Uyeno? 5 *Protopanderodus* sp. indet.	Caradocian (middle Middle-middle Late Ordovician; Blackriveran-middle Maysvillian).	3	Indeterminate; the taphonomy of the fauna indicates a postmortem hydraulic winnow and the species association indicates derivation from at least a middle shelf or deeper water setting.	1.5 kg of rock processed (0 g +20 and 11 g 20-200 mesh insoluble residue). HMC: Chiefly phosphatized composite grains and composite phosphatic ferruginous grains and flakes.
9 (97TT-59)	41°06'43" 116°15'12" Beaver Peak, Elko County	Slaven Chert(?). Brown-black micrite with abundant carbonaceous material along seams. Interbedded with thick chert sequence below tectonically overthrust package of quartzarenite.	**BARREN**.				1.6 kg of rock processed (480 g +20 and 116 g 20-200 mesh insoluble residue). HMC: Chiefly composite ferruginous flakes and rare phosphatized composite grains and phosphatized spine steinkerns.
10 (97TT-63; 33386-PC)	41°04'58" 116°15'25" Beaver Peak, Elko County	Strathearn Formation. Buff-gray micrite, approximately 10-15 m thick, above basal chert-pebble conglomerate. Thin section contains abundant fusulinids.	*Hindeodus minutus* (Ellison)? 4 Pa, 2 Pb, 1 Sa, and 1 Sc elements *Streptognathodus* sp. 12 Pa and 1 M elements 19 indet. bar, blade, and platform fragments	Late Pennsylvanian-early Early Permian.	2	Streptognathodid-hindeodid biofacies; at least middle shelf or deeper water depositional setting.	1.2 kg of rock processed (20 g +20 and 28 g 20-200 mesh insoluble residue). HMC: Chiefly phosphatic brachiopod fragments and composite ferruginous flakes and grains, and minor ichthyoliths.
11 (97TT-64; 33387-PC)	41°05'11" 116°15'21" Beaver Peak, Elko County	Strathearn Formation. Same stratigraphic position as 97TT-63 but approximately 30 m thick at this locality. Buff-gray micrite with calcareous mud lumps and shell fragments.	*Streptognathodus* sp. indet. 4 juvenile Pa elements 1 unassigned Sc element 17 indet. bar, blade, and platform fragments	Late Pennsylvanian-early Early Permian.	1.5	Indeterminate (too few conodonts); the conodonts indicate a normal-marine depositional setting.	1.6 kg of rock processed (15 g +20 and 77 g 20-200 mesh insoluble residue). HMC: Chiefly phosphatic brachiopod fragments and composite dolomitic ferruginous grains.
12 (97TT-65)	41°05'48" 116°15'10" Beaver Peak, Elko County	Strathearn Formation. Dolomitic limestone with abundant angular silt-sized fragments of monocrystalline quartz. On strike with 97TT-63 and -64.	1 unassigned Sc element fragment 5 indet. bar, blade, and platform fragments	Silurian-Triassic, most probably Late Pennsylvanian-early Early Permian.	1.5-2	Indeterminate (too few conodonts).	1.8 kg of rock processed (1.0 kg +20 and 85 g 20-200 mesh insoluble residue). HMC: Chiefly dolomitic and baritic composite grains and minor weathered euhedral pyrite and composite ferruginous flakes.

continued

Table 1. *Continued*

Map Loc. No. (Field No.; USGS Colln. No.)	Latitude N. Longitude W. 7.5 Min. Quadrangle	Stratigraphic Unit and Lithology	Conodont Fauna	Age	CAI	Conodont Biofacies and Depositional Environment	Sample Weight and Composition of Heavy-Mineral Concentrate (HMC)
13 (97TT-67; 33388-PC)	41°04'40" 116°15'12" Beaver Peak, Elko County	Strathearn Formation. Silty to sandy sparry limestone near top of Beaver Peak and approximately 200 m stratigraphically above samples 97TT-63 to -65.	*Mesogondolella bisselli* (Clark and Behnken) 2 Pa elements *Mesogondolella* sp. indet. 25 Pa element fragments *Streptognathodus* sp. indet. 6 Pa element fragments *Sweetognathus whitei* (Rhodes) 4 Pa element fragments 1 unassigned M element 30 indet. bar, blade, and platform fragments	latest Sakmarian-earliest Artinskian (late Wolfcampian; middle Early Permian).	2.5	Mesogondolellid; normal-marine, middle shelf or deeper water depositional setting.	1.8 kg of rock processed (100 g +20 and 82 g 20-200 mesh insoluble residue). HMC: Chiefly weathered pyrite euhedra, phosphatized bioclasts, phosphatic brachiopod fragments, and minor composite ferruginous grains and ichthyoliths.
14 (97TT-80)	41°04'02" 116°16'35" Beaver Peak, Elko County	Strathearn Formation. Drab light-gray to buff 2-m-thick sequence of silty limestone including abundant angular fragments of monocrystalline quartz.	3 indet. bar fragments	Silurian-Triassic.	1-1.5	Indeterminate (too few conodonts).	2.2 kg of rock processed (1.46 kg +20 and 52 g 20-200 mesh insoluble residue). HMC: Composition not recorded.
15 (97TT-82; 33389-PC)	41°03'27" 116°17'31" Beaver Peak, Elko County	Strathearn Formation. Dolomitic siltstone.	*Streptognathodus* sp. indet. 1 juvenile Pa element fragment	late Morrowan-earliest Artinskian, most probably no older than Missourian (Middle Pennsylvanian-middle Early Permian, most probably no older than middle Late Pennsylvanian).	1.5-2	Indeterminate (too few conodonts).	2.7 kg of rock processed (180 g +20 and 132 g 20-200 mesh insoluble residue). HMC: Chiefly barite and lesser ferruginous barite and baritized composite grains and minor dolomite.
16 (97TT-83; 33390-PC)	41°03'27" 116°17'20" Beaver Peak, Elko County	Strathearn Formation. Dolomitic siltstone including some rounded monocrystalline quartz sand grains. Sparry matrix partly replaced by barite.	*Polygnathus* sp. indet. 1 incomplete Pa element of Middle-Late Devonian morphotype (upper surface mostly covered by adventitious quartz grains) 1 juvenile Pa element fragment of Carboniferous-Permian morphotype 4 indet. bar, blade, and platform fragments	late Paleozoic (Late Mississippian-Early Permian) with redeposited Middle-Late Devonian conodonts.	1.5-2	Indeterminate (too few conodonts).	2.7 kg of rock processed (120 g +20 and 363 g 20-200 mesh insoluble residue). HMC: Chiefly baritized composite grains and minor dolomite.
17 (97TT-84; 33391-PC)	41°03'34" 116°17'34" Beaver Peak, Elko County	Strathearn Formation. Sparry dolomitic siltstone rests unconformably above tectonically emplaced quartzarenite of Vinini Formation.	*Streptognathodus* sp. indet. 16 Pa element fragments (chiefly juveniles and subadults) 1 digyrate Sa element fragment 11 indet. bar, blade, and platform fragments	late Morrowan-Sakmarian, probably Missourian-Sakmarian (probably Late Pennsylvanian-early Early Permian.	1.5-2	Postmortem transport from or within the streptognathodid biofacies suggesting middle shelf or deeper water depositional setting.	4.2 kg of rock processed (300 g +20 and 337 g 20-200 mesh insoluble residue). HMC: Chiefly barite and lesser phosphatic composite grains and minor dolomite.
18 (97TT-85)	41°03'39" 116°17'21" Beaver Peak, Elko County	Strathearn Formation. Flaggy, brown-gray dolomitic siltstone.	**BARREN.**				3.0 kg of rock processed (2.5 kg +20 and 24 g 20-200 mesh insoluble residue). HMC: Chiefly barite, rock fragments and minor ferruginous rock fragments and composite ferruginous flakes.
19 (98TT008 12630-SD)	41°01'12.5" 116°17'35.0" Beaver Peak, Elko County	Slaven Chert(?). Buff-weathering, gray dolostone interbedded with black, well-bedded chert.	5 incomplete juvenile Pa elements *Ancyrodella* sp. indet. 25 *Delotaxis* sp. elements 6 P elements *Icriodus* sp. 3 Pa elements *Palmatolepis gigas paragigas* Ziegler and Sandberg 5 Pa elements *Palmatolepis punctata* Miller and Youngquist *Palmatolepis* spp. indet. 125 juvenile and incomplete Pa and 7 Pb elements 25 Pa elements (chiefly juveniles) *Polygnathus timanicus* Ovnatonova 30 Pa elements *Polygnathus webbi* Stauffer 46 Pa elements *Polygnathus* spp. UNASSIGNED ELEMENTS: 22 Pb (4 morphotypes), 22 M (+5 morpho-types), 15 Sa (+5 morphotypes), 5 Sb (4 morphotypes), and 22 Sc (+6 morphotypes) 410 indet. bar, blade, and platform fragments	Lower *Pa. rhenana* Subzone (early late Frasnian)	2.5-3	Palmatolepid-polygnathid biofacies: outer shelf or deeper water depositional setting. Some components of this faunule are postmortem transportees from relatively shallow-water habitats (e.g., *Ancyrodella* and *Icriodus*).	2.5 kg of rock processed (240 g +20 and 260 g 20-200 mesh insoluble residue). HMC: Chiefly anhedral to subhedral dolomite, pyritic carbonaceous flakes, conodonts (complete, small juveniles to gerontic adults, and as fragments), and minor composite ferruginous flakes.

continued

Table 1. *Continued*

Map Loc. No. (Field No.; USGS Colln. No.)	Latitude N. Longitude W. 7.5 Min. Quadrangle	Stratigraphic Unit and Lithology	Conodont Fauna	Age	CAI	Conodont Biofacies and Depositional Environment	Sample Weight and Composition of Heavy-Mineral Concentrate (HMC)
20 (98TT021 11554-CO)	41°00'22.5" 116°17'33.5" Beaver Peak, Elko County	Vinini Formation. Gray, silty micrite about 1-2 m thick, interbedded with black chert.	All conodonts are very small and (or) incomplete. *Amorphognathus* sp. indet. 1 Sb element and 2 small bar fragments 3 *Belodina* sp. indet. juvenile elements 1 *Cornuodus*? sp. indet. element 4 *Drepanoistodus* sp. indet. juvenile elements *Paroistodus? mutatus* (Branson and Mehl) 10 M and 20 S elements 3 *Panderodus* sp. indet. juvenile elements *Periodon* sp. indet. 2 Sb and 3 Sc elements UNASSIGNED ELEMENTS: 1 P, 2 coniform M, and 1 Sb 33 indet. chiefly coniform and lesser bar, blade, and platform fragments	Based on the *Periodon* elements, this collection can be no younger than early Ashgillian or older than late early Caradoc (middle Middle-middle Late Ordovician).	~2 or 3; conodonts are too small for an accurate determination.	Postmortem transport from or within a slope or basinal depositional setting. The taphonomy of this faunule suggests a distal winnow.	4.8 kg of rock processed (120 g +20 and 61 g 20-200 mesh insoluble residue). HMC: Chiefly composite ferruginous grains with and without pyrite, lesser composite phosphatized grains with and without pyrite, and scarce pyritized sponge spicules.
21 (98TT023)	41°00'35.5" 116°17'32.5" Beaver Peak, Elko County	Vinini Formation. Laminated gray micrite, weathering light gray to buff gray, about 0.5 m thick; interbedded with black chert.	**BARREN**.				4.5 kg of rock processed (10 g +20 and 134 g 20-200 mesh insoluble residue). HMC: Chiefly composite ferruginous grains, minor phosphatized composite grains, and rare pyrite.
22 (98TT027)	41°00'46.0" 116°16'51.0" Beaver Peak, Elko County	Vinini Formation. Black micrite, approximately 3-5 m thick, immediately below Elder Sandstone.	**BARREN**.				2.9 kg of rock processed (20 g +20 and 99 g 20-200 mesh insoluble residue). HMC: Chiefly phosphatized composite silt-sized to very fine sand-sized grains and rare pyritized sponge spicules.
23 (98TT028)	41°01'04.5" 116°17'16.0" Beaver Peak, Elko County	Elder Sandstone. Light-gray, calcareous siltstone, approximately 2 m thick; relatively thick-bedded; shows 10-12 cm between parting surfaces parallel to bedding.	**BARREN**.				2.8 kg of rock processed (2.4 kg +20 and 27 g 20-200 mesh insoluble residue). HMC: Chiefly ferroan dolomite, minor nonferroan dolomite and composite ferruginous flakes, and rare carbonaceous schistose rock fragments.
24 (98TT034 12631-SD)	41°05'06.0" 116°21'28.0" Beaver Peak, Elko County	Slaven Chert(?). Poorly exposed, buff-weathering, dark-gray, silty micrite.	1 small P element sliver of an icriodontid	Likely Devonian, but forms with icriodontid nodes on Pa elements occur from the middle Middle Ordovician through the Devonian.	2 or 3	Indeterminate (too few conodonts).	0.6 kg of rock processed (0.5 kg +20 and 70 g 20-200 mesh insoluble residue). HMC: Chiefly phosphatized chert and carbonaceous chert and common well-rounded brown and lesser pink zircon.
25 (98SF-12 11555-CO)	40°59'10" 116°15'22" Rodeo Creek NE, Eureka County.	Vinini Formation. Limestone bed within a thick black shale of the Vinini Formation. The limestone bed is a few meters below a chert bed that is considered to be Elder Formation. Contact between shale with one limestone bed and the Elder may be a thrust fault.	1 *Ansella* sp. indet. element 1 belodinid 3 *Drepanoistodus suberectus* (Branson and Mehl) elements 5 *Panderodus* sp. elements *Periodon aculeatus* Hadding 4 Pa, 3 Pb, 9 M, 2 Sa, 2 Sb, and 4 Sc elements 1 Pa element *Plectodina* sp. indet. 7 *Protopanderodus insculptus* elements 3 fragments *Protopanderodus* sp. indet. 2 *Scabbardella altipes* (Henningsmoen) elements 34 indet. bar, blade, platform and coniform fragments	No older than Ashgillian, based on the occurrence of *Pr. insculptus* which originates in the middle(?) Maysvillian. The occurrence of *Periodon aculeatus* (which is not known to extend beyond the middle Caradoc) suggests redeposition, thus the age designation "No older than." All other species are long ranging and extend through the Ashgillian, Late Ordovician.	3	Because of reworking, this fauna cannot be used for biofacies analysis. However, all of the conodonts except the belodinid and plectodinid, regardless of their age, are cosmopolitan and typical of outer shelf or deeper water environments.	4.7 kg of rock processed (500 g +20 and 52 g 20-200 mesh insoluble residue). HMC: Chiefly composite phosphatized grains, composite ferruginous flakes and grains, and minor anhedral dolomite.

continued

Table 1. *Continued*

Map Loc. No. (Field No.; USGS Colln. No.)	Latitude N. Longitude W. 7.5 Min. Quadrangle	Stratigraphic Unit and Lithology	Conodont Fauna	Age	CAI	Conodont Biofacies and Depositional Environment	Sample Weight and Composition of Heavy-Mineral Concentrate (HMC)
26 (98SF-13 12632-SD)	40°59'10" 116°15'22" Rodeo Creek NE Eureka County.	Elder Sandstone Limestone bed in interval of olive to light-gray, locally silty, siliceous shale. Limestone crops out a few meters above a prominent chert bed, which in turn is above the Vinini Formation.	3 *Dapsilodus obliquicostatus* (Branson and Mehl) elements 1 indet. coniform fragment	Llandovery-early Lochkovian.	~2 or 3	Indeterminate (too few conodonts).	4.7 kg of rock processed (100 g +20 and 48 g 20-200 mesh insoluble residue). HMC: Composite chiefly ferruginous grains and fresh and weathered mainly euhedral pyrite.
27 (99TT003)	41°04'31" 116°17'50" Beaver Peak, Elko County	Strathearn Formation of Dott (1955); Pennsylvanian or Permian. Poorly exposed buff-weathering, calcareous siltstone, possibly dolomitic. Nearby exposed sequence of rocks includes 1- to 2-m-thick brown to dark-gray siltstone. interbedded with black, well-bedded chert.	**BARREN**				1.3 kg of rock processed (1.2 kg +20 and 23 g 20-200 mesh insoluble residue). HMC: Chiefly ferruginous and nonferruginous dolomitic composite siltstone grains.
28 (99TT004 33455-PC)	41°04'31" 116°17'50" Beaver Peak, Elko County	Strathearn Formation of Dott (1955); Pennsylvanian or Permian. Same loc. as 99TT003. Brownish-gray, yellow-ochre-weathering, laminated, calcareous, possibly dolomitic siltstone. Sampled interval is 2- to 3-m thick and about 6 m topographically below 99TT003.	1 incomplete juvenile Pa element *Streptognathodus* sp. indet.	Middle Pennsylvanian-early Early Permian	1.5	Indet. (too few conodonts).	2.42 kg of rock processed (2.2 g +20 and 47 g 20-200 mesh insoluble residue). HMC: Chiefly ferruginous quartz grains, and weathered pyrite euhedra.
29 (99TT176)	41°02.09' 116°16.6' Beaver Peak, Elko County	Elder Sandstone of Gilluly and Gates (1965); Silurian. Buff-weathering dolomitic sandy limestone; 8-10 m of section along ~20 m of ridgeline.	**BARREN**				2.16 kg of rock processed (2.1 kg + 20 and 37 g 20-200 mesh insoluble residue). HMC: Chiefly composite siltstone grains, pyritic and (or) ferruginous composite silstone grains, and dolomite fragments.
30 (99TT221; 11631-CO)	41°00.43' 116°17.57' Beaver Peak, Elko County	Vinini Formation (?); Ordovician. Lens of 30-m-wide black partially recrystallized limestone within sequence of black chert that contains lenses of limestone as much as 15 cm x 2 cm wide.	*Belodina compressa* (Branson and Mehl) 2 M and 6 S elements 4 *Belodina* sp. indet. juvenile elements 8 *Drepanoistodus suberectus* (Branson and Mehl) elements 11 *Panderodus gracilis* (Branson and Mehl) elements *Paroistodus mutatus* (Branson and Mehl) 8 M and 38 S elements *Periodon aculeatus* Hadding 2 Pa, 5 M, 1 Sb, and 2 Sc elements 10 *Protopanderodus liripipus* Kennedy, Barnes, and Uyeno elements UNASSIGNED ELEMENTS: 2 M (cordylodiform) and 1 Sc 43 indet. bar, blade, platform, and coniform fragments and juveniles	*Belodina compressa* Zone into *Phragmodus undatus* Zone (middle Caradocian). Conodonts indicate sample is likely from the Vinini Formation	*3*	Mixed biofacies; postmortem transport of open-marine, chiefly cosmopolitan small conodonts within or from an outer shelf or deeper water environment. Slope or basin facies also suggested by sponge spicules and radiolarians.	2.98 kg of rock processed (31 g +20 and 28 g 20-200 mesh insoluble residue). HMC: Chiefly composite carbonaceous-pyritic-argillaceous grains, composite pyritic ferruginous flakes and grains and rare conodonts, phosphatized gastropod steinkerns, phosphatic brachiopod fragments, and pyritized sponge spicules and radiolarians (?).

Table 1. *Continued*

GRAPTOLITES

Map Loc. No. (Field No.)	Latitude N. Longitude W. 7.5 Min. Quadrangle	Stratigraphic Unit and Lithology	Graptolite Fauna	Age	Remarks
31 (BC-BIO-1)	41°06.677' 116°20.829' Beaver Peak, Elko County	Vinini Formation; shale in green chert interbedded in quartzarenite of Coyote allochthon	*Cryptograptus schaeferi* *Glossograptus* sp. *Nemagraptus* sp. (?) *Leptograptus* *Pseudoclimacograptus* sp.	*Gracilis* graptolite zone 11 to zone 12 of Berry (1960) late Middle Ordovician	
32 98SF-4 (TT-G-01)	41°00'29.55" 116°15'47.17" Beaver Peak, Elko County	Elder Sandstone; flaggy dolomitic and calcareous generally olive gray-green siltstone	98SF-4 *Bohemograptus bohemicus* *Saetograptus willowensis* TT-G-01: *Bohemograptus bohemicus* *Pristiograptus dubius*	*B. bohemicus* graptolite zone of upper Ludlow, early Late Silurian	More than 30 chip samples comprise 98SF-4, many with several specimens, collected from roadcut. TT-G-01, three well preserved specimens. Same fauna reported by Berry and Murphy (1975) from middle of Devonian and Silurian Roberts Mountains Formation in central Nevada.
33 (98SF-11)	40°59.592' 116°15.558' Rodeo Creek NE, Elko County	Vinini Formation; black shale subunit of shale and chert unit	*Glossograptus ciliatus* *Cryptograptus tricornis (schaeferi)* *Pseudoclimacograptus angulatus* *Didymograptus* sp.	*Hustedeograptus teretiusculus* graptolite zone 10 of Berry (1960) Middle Ordovician	Shale outcrop, approximately 6 m above base of steep slope. Locality approximately 10 m lower on slope than 98SF-14. Roughly 70 shale chips, most with more than one specimen; good preservation; periderm commonly largely complete; few specimens are in relief.
33 (98SF-14)	40°59.592' 116°15.558' Rodeo Creek NE, Elko County	Vinini Formation; black shale subunit of shale and chert unit	*Glossograptus ciliatus* *Pseudoclimacograptus modestus* *Didymograptus* sp.	*Hustedeograptus teretiusculus* graptolite zone 10 of Berry (1960) Middle Ordovician	Shale outcrop, approximately 10 m above 98SF-11. Roughly 30 shale chips; preservation moderate to good.
34 (98SF-18)	41°00.04' 116°17.143' Beaver Peak, Elko County	Vinini Formation; near top of shale and chert unit	(?) *Normalograptus* sp.	*Normalograptus extraordinarius or N. persculptus* zones, likely upper zone 15 of Berry (1960) late Late Ordovician	Two small graptolite fragments found in fine-grained, blocky weathering, clay-rich limestone; limestone likely same stratum as map loc. 30 (sample no. 99TT 221).

RADIOLARIANS

Map Loc. No. (Field No.)	Latitude N. Longitude W. 7.5 Min. Quadrangle	Stratigraphic Unit and Lithology	Radiolarian Fauna	Age	Remarks
35	41°01.836' 116°17.143' Beaver Peak, Elko County	Slaven Chert	Fauna not identified in Dubé (1988)	Late Devonian, probably Famennian	Sample locality in Coyote barite mine. Radiolaria obtained from chert interbedded with massive barite at mine (Dubé, 1988).
36 (00TT035)	41°02.84' 116°17.053' Beaver Peak, Elko County	Mélange unit of Slaven Chert	Entactiniids identified by T.G. Theodore	Devonian	Abundant spherical radiolaria showing, in thin section, well-preserved trigonal spines in chert matrix that cements fragments of chert; also show well-developed microspheres.

FUSULINIDS

Map Loc. No. (Field No.)	Latitude N. Longitude W. 7.5 Min. Quadrangle	Stratigraphic Unit and Lithology	Fusulinid Fauna	Age	Remarks
6 (97TT-51)	41°05'15" 116°17'25" Beaver Peak, Elko County	Strathearn Formation. Approximately 1-m-thick bed near base of chert-pebble conglomerate sequence resting on Devonian chert mélange unit of Slaven Chert. Thin section contains abundant fusulinids	*Triticites newelli* Burma *Pseudofusinella* cf. *P. utahensi* Thompson	late Missourian, middle Late Pennsylvanian	Limestone lens hosts phenomenal concentration of fusulinids near base in a zone of carbonate sand the upper and lower contacts of which grade into surrounding bioclastic sands that contain abundant fragments of echinoderm spines, crinoids, brachiopods, and the colonial rugose coral *Durhamina*. The latter are quite rare in Pennsylvanian sequences in the western United States (Theodore and others, 1998). Overall depositional environment of limestone lens is that of a shallow shoal, and, when compared to the middle shelf environments determined for most of the overlying sequence of the Strathearn Formation, suggests a progressive deepening or drowning with time.

onlap Ordovician quartzarenite in the upper plate of the Coyote thrust. These strata also lap across the leading edge of the Coyote thrust where it crops out southwest of BP. The unconformity between the upper conglomerate of the Strathearn Formation and underlying quartzarenite of the Vinini Formation is well exposed on the ridgeline southwest of BP (fig. 2). Ordovician quartzarenite in the upper plate of the Coyote thrust in the BP Quadrangle probably is somewhat older than the quartzarenite in the upper unit of the Vinini Formation in the Roberts Mountains (Finney and Perry, 1991; Finney and others, 2000), because quartzarenite in the upper plate of the Coyote thrust apparently belongs to graptolite Zone 11 of Berry (1960) whereas quartzarenite of the upper unit of the Vinini in the Roberts Mountains belongs to Zone 13. Onlap of quartzarenite in the upper plate of the Coyote thrust by chert-quartzarenite pebble conglomerate belonging to the Strathearn Formation marks an important intraformational unconformity within the unit (Theodore and others, 2003). Ordovician quartzarenite also is present above Late Devonian rocks near Beaver Creek, approximately 5 km northeast of BP (Dubé, 1987). These relations constrain emplacement of the upper plate of the Coyote thrust to a relatively narrow time interval between late Virgilian (middle Late Pennsylvanian) to latest Sakmarian-earliest Artinskian (middle Early Permian) (Theodore and others, 1998, 2000b). We envisage that various parts of the Strathearn also were involved structurally with a nearby belt of lower Paleozoic rocks that were advancing towards the southeast (present day coordinates) in a largely shallow marine environment. Thus, the lower Paleozoic rocks, in places, overrode their own detritus (Berger and others, 2001). In the Carlin Canyon area, Cashman and others (2000, 2001) have documented a Late Pennsylvanian to Early Permian northwest-southeast shortening that is temporally equivalent to the similarly oriented trend of thrusting near BP.

Narrow Jurassic(?) dikes of relatively short strike length are present in two localities southeast of the Boulder Creek fault. These are the only intrusive rocks mapped in the quadrangle. The two poorly exposed dikes southeast of the Boulder Creek fault intrude conglomeratic strata of the lower Strathearn Formation. These intensely altered alkali granite and monzonite dikes contain narrow seams of yellow limonite (jarosite?)+Fe-oxide mineral(s) as well as relatively abundant white mica. All of these dikes presumably are younger than the thrust faults described above.

Tertiary as well as Tertiary and Quaternary unconsolidated deposits are present mostly in the western part of the quadrangle. Tertiary and Quaternary unconsolidated fanglomeratic deposits near Boulder Creek form the disjointed upper reaches of a broad fan that crops out widely to the southwest in the SRF Quadrangle. These deposits were previously assigned by Theodore and others (1998, 2000a, 2000b) to an upper unit of the Miocene Carlin Formation of Regnier (1960), which also crops out widely in the SRF Quadrangle.

Faults

Geometry and structural relations of faults in the area conform surprisingly well to a number of regionally extensive geologic features. For example, faults of the Coyote thrust system generally strike east and dip at shallow angles to the north and are probably correlative with the Lander thrust in the Shoshone Range as described above. The basal or master surface of the Coyote thrust is inferred to bend to the northeast around the northwest flank of BP. This inference is based on presence of a number of down-dropped slivers of quartzarenite in the southwest quadrant of the quadrangle. The imbricate Little Jack thrust probably is slightly older and structurally lower than the Coyote thrust—the mélange fabric in the Slaven Chert overprints soft sediment deformation and may owe its origins to early tectonism of the Antler orogen during the Late Devonian near the onset of contractional deformation along the RMT. Further, the Little Jack thrust in the southwest part of the quadrangle is shown as having been offset along a number of steeply north-dipping normal faults. However, it is equally plausible that these steeply dipping faults represent ramps in the trace of the Little Jack thrust (J. Faulds, written commun., 2002). The structurally highest thrust fault in the quadrangle is the Squaw Creek thrust near the north edge of the quadrangle. This thrust is believed to represent a minor imbricate thrust fault related to the subjacent Coyote thrust system.

Two major high-angle northeast-striking faults in the area, the Toro and the Boulder Creek faults, probably are associated with early-stage deformation along the Crescent Valley-Independence Lineament (CVIL) of Peters (1998, 2000, 2003). The northeast-striking, major fault strand of the CVIL is present approximately 8 km east of the quadrangle. The Boulder Creek and Toro faults show significant left-lateral separations along their traces that respectively measure approximately 3 km and 0.8 km—the former is a measure of separation of the leading edge of quartzarenite in the upper plate of the Coyote thrust and the latter on separations of the Coyote thrust at two places along Boulder Creek. These separations probably are related to late Paleozoic shortening associated with emplacement of the Coyote allochthon, because the bulk of the separations along the Boulder Creek fault must have occurred prior to final emplacement of the Coyote allochthon, as evidenced by lack of apparent offset of the trace of the Squaw Creek thrust. Thus, we suggest a direct linkage in the area between regional-scale low-angle thrust faults and some northeast-striking strike-slip faults.

A number of generally north-striking normal and high-angle reverse faults also are present in the BP Quadrangle. Many of the normal faults most likely are related to Tertiary extensional tectonism that has affected the region. Displacements along individual Tertiary faults may measure as much as several hundred meters.

Folds

Folds in the quadrangle are marked by a wide variety of orientations and styles. Broad, relatively open, large folds characterize the well-bedded unit of the Slaven Chert, and these folds generally have northerly trending fold hinge lines. This unit of the Slaven Chert also contains fairly widespread outcrop-scale folds. The broad folds, as well as their outcrop-scale counterparts that have similar orientations, probably owe their origins to generally east-west shortening associated with initial emplacement of the RMT allochthon during the Late Devonian and/or Early Mississippian, whereas middle Late Pennsylvanian and middle Early Permian shortening associated with the Coyote thrust apparently has a south-southeast component of shortening. West-northwest-striking and northeast-dipping faults and similarly oriented folds in the Betze-Post gold orebody, approximately 2 km south of the southwest corner of the BP Quadrangle, also may have formed during late Paleozoic shortening (Bettles, 2002). The hinge lines of some broad open folds in the mélange unit in the BP Quadrangle appear to bend into parallelism near the trace of the Coyote thrust. In addition, sparse broad open folds in quartzarenite of the Vinini Formation that makes up the upper plate of the Coyote thrust have east-trending hinge lines. Such folds may owe their origins to a northerly component of shortening associated with emplacement of the upper plate of the Coyote thrust.

DISCUSSION

The most important unit to crop out in the BP Quadrangle is the middle Late Pennsylvanian and middle Early Permian Strathearn Formation. Conglomerates belonging to the Strathearn Formation represent submarine fanglomerates derived from a largely southeastwards advancing allochthonous lobe of mostly quartzarenite of the Ordovician Vinini Formation (Berger and others, 2001; Theodore and others, 2003). Conodont biofacies of the Strathearn Formation are marine indicative of middle shelf or deeper environments (Theodore and others, 1998). A middle Early Permian upper conglomerate unit, highest unit recognized in the Strathearn Formation (Theodore and others, 2003), as well as similarly aged dolomitic siltstone, onlap directly onto quartzarenite that comprises the allochthon of the Coyote thrust (figs. 2 and 3). Chert fragments in the conglomerates were derived mostly from Devonian Slaven Chert, including a widespread thick mélange unit of the Slaven in the footwall of the Coyote thrust.

Paleo-environmental indicators—including conodont biofacies as well as clast composition, roundness, and aspect ratios—are compatible with conglomerate units of the Late Pennsylvanian and middle Early Permian Strathearn having mixed source areas within the allochthon of the RMT (Berger and others, 2001; Theodore and others, 2003). Further, widespread geologic evidence in the greater BP area indicates that the allochthon of the RMT was reactivated sometime following initial deposition of the middle Late Pennsylvanian lower conglomerate unit of the Strathearn Formation. If structural relations of the allochthon of the RMT at BP are not considered to reflect a reactivation of an already emplaced tectonic lobe, then expansion of the Antler orogeny to include shortening as young as middle Early Permian requires the Antler orogeny to have lasted approximately 100 million years. Early Permian thrust faults elsewhere in the western Cordillera also have been reported in east-central California (Stevens and Stone, 1988). Such contractional reactivation, including that in the greater BP area, probably occurred in conjunction with extensive late Paleozoic tectonism in western North America associated with the Ancestral Rockies (see also Dickinson, 2001).

Much of the late Paleozoic tectonism in the region heretofore was envisaged to be extensional and/or epeirogenic (Ketner, 1977). Thus, low-angle thrusting at BP during the late Paleozoic apparently contributed toward exhumation of a lobe of the Coyote thrust that, in turn, provided a source for much of the quartzarenite detritus deposited preferentially in the upper parts of the Strathearn Formation (Berger and others, 2001). Such a tectono-sedimentary conceptual model is similar to that proposed for development of fan-delta wedges in northeast Spain along the margin of the Ebro basin adjacent to the Catalan Coast Ranges (Lopez-Blanco and others, 2000), and the coarse clastics associated with the Antler foreland basin (Harbaugh and Dickinson, 1981). We cannot evaluate how much, if any, subsidence of the Strathearn basin is a result of downflexure of the underlying supracrustal rocks due to structural load from the advancing late Paleozoic thrust sheets (see also Price, 1973).

Regionally, contractional deformation dating from the late Paleozoic apparently involves reactivation of rocks previously emplaced along the RMT—this deformation affects rocks of the Strathearn Formation. We further suggest that the roughly east-striking late Paleozoic thrust faults in the area most likely represent episodic Ancestral Rockies-age shortening and uplift that may have been associated with docking of the Ouachita-Marathon belt (Oldow and others, 1989; Ye and others, 1996; Geslin, 1998; Dickinson, 2001; see also, Saucier, 1997; Cluer, 1999). Previously, Burchfiel and Davis (1972) suggested an episodic eastward subduction of oceanic crust during the Antler orogeny. As described above, the Coyote thrust may be correlative with the Lander thrust in the Shoshone Range. Somewhat farther to the west in the Edna Mountains, Erickson and Marsh (1974) documented the presence of deformation of Late Pennsylvanian or Early Permian age. Folded strata involving the Middle Pennsylvanian Battle Formation, the Late Pennsylvanian Highway Limestone, and the Pennsylvanian and Permian Antler Peak Limestone make up the upper plate of the Iron Point thrust (Erickson and Marsh, 1974). This deformation must have occurred prior to deposition of the Middle and/or Late(?) Permian Edna Mountain Formation in the area. Elsewhere during the late Paleozoic, protracted shortening and uplift were marked by multiple unconformities of regional extent suggesting active tectonism throughout this period of time (Snyder and others, 2000).

REFERENCES

Berger, V.I., Singer, D.A., and Theodore, T.G., 2001, Sedimentology of the Pennsylvanian and Permian Strathearn Formation, northern Carlin trend, Elko County, Nevada: U.S. Geological Survey Open-File Report 01-402, 99 p.

Berry, W.B.N., 1960, Graptolite faunas of the Marathon region, west Texas: Texas University, Bureau of Economic Geology, Publication 6005, 179 p.

Berry, W.B.N., and Murphy, M.A., 1975, Silurian and Devonian graptolites of central Nevada: University of California, Berkeley, Publications in Geological Sciences no. 110, 109 p.

Bettles, K., 2002, Exploration and geology, 1962 to 2002, at the Goldstrike property, Carlin trend, Nevada, *in* Goldfarb, R.J., and Nielsen, R.L., eds., Integrated methods for discovery: Global exploration in the twenty-first century: Society of Economic Geologists Special Publication, no. 9, p. 275–298.

Burchfiel, B.C., and Davis, G.A., 1972, Structural framework and evolution of the southern part of the Cordilleran orogen, western United States: American Journal of Science, v. 272, no. 2, p. 97–118.

Cashman, P.H., Trexler, J.H., Jr., Snyder, W.S., and Davydov, V.I., 2000, Geometry and kinematics of Late Pennsylvanian to Early Permian deformation at Carlin Canyon, central Nevada [abs.]: Geological Society of America Abstracts with Programs, v. 32, no. 7, p. A-316.

Cashman, P.H., Trexler, J.H., Jr., Snyder, W.S., and Davydov, V.I., 2001, Upper Paleozoic deformation events in the Carlin area, Nevada, *in* Shaddrick, D.R., Zbinden, E., Mathewson, D.C., and Prenn, C., eds., Regional tectonics and structural control of ore: The major gold trends of northern Nevada: Geological Society of Nevada, Special Publication no. 33, p. 343–348.

Cluer, J.K., 1999, Future of gold exploration in the Roberts Mountains allochthon, Nevada: Role of structural geology and biostratigraphy [abs.]: Geological Society America Abstracts with Programs, v. 31, no. 4, March, 1999, p. A-7.

Cluer, J.K., Cellura, B.R., Keith, S.B., Finney, S.C., and Bellert, S.J., 1997, Stratigraphy and structure of the Bell Creek nappe (Antler orogen), Ren property, northern Carlin trend, Nevada: Reno, Nevada, Nevada Petroleum Society, 1997 Fall Field Trip Guide, p. 41–54.

Coats, R.R., 1987, Geology of Elko County: Nevada Bureau of Mines and Geology Bulletin 101, 112 p.

Dewitt, Alexander, 2001, Structural architecture of the Jerritt Canyon district and gold deposits, *in* Shaddrick, D.R., Zbinden, E., Mathewson, D.C., and Prenn, C., eds., Regional tectonics and structural control of ore: The major gold trends of northern Nevada: Geological Society of Nevada, Special Publication no. 33, p. 135–145.

Dickinson, W.R., 2001, Tectonic setting of the Great Basin through geologic time: Implications for metallogeny, *in* Shaddrick, D.R., Zbinden, E., Mathewson, D.C., and Prenn, C., eds., Regional tectonics and structural control of ore: The major gold trends of northern Nevada: Geological Society of Nevada, Special Publication no. 33, p. 27–53.

Doebrich, J.L., 1994, Preliminary geologic map of the Galena Canyon Quadrangle, Lander County, Nevada: U.S. Geological Survey Open-File Report 94-664, 1:24,000.

Dott, R.H., Jr., 1955, Pennsylvanian stratigraphy of Elko and northern Diamond Ranges, northeastern Nevada: American Association of Petroleum Geologists Bulletin, v. 39, no. 11, p. 2,211–2,305.

Dubé, T.E., 1987, Setting and origin of exhalative bedded barite and associated rocks of the Roberts Mountains allochthon in north-central Nevada [M.S. thesis]: University of Washington, Seattle, 76 p.

Dubé, T.E., 1988, Tectonic significance of Upper Devonian igneous rocks and bedded barite, Roberts Mountains allochthon, Nevada, U.S.A., *in* McMillan, N.J., Embry, A.F., and Glass, D.J., eds., Devonian of the world-Volume II: Sedimentation: Calgary, Alberta, Proceedings of the Second International Symposium on the Devonian System, Canadian Society of Petroleum Geologists Memoir, p. 235–249.

Emmons, S.F., 1877, Region north of the Humboldt River, *in* King, Clarence, Report of the U.S. Geological Exploration of the Fortieth Parallel: U.S. Army Engineer Department Professional Paper 18, Descriptive Geology v. 2, p. 590–617.

Erickson, R.L., and Marsh, S.P., 1974, Paleozoic tectonics in the Edna Mountain quadrangle, Nevada: U.S. Geological Survey Journal of Research, v. 2, no. 3, p. 331–337.

Ettner, D.C., 1989, Stratigraphy and structure of the Devonian autochthonous rocks, north-central Carlin trend of the southern Tuscarora Mountains, northern Eureka County, Nevada [M.S. thesis]: Idaho State University, Pocatello, 177 p.

Finney, S.C., Noble, P., and Cluer, J.K., 2000, Lower Paleozoic stratigraphy and structure of central Nevada: Comparisons and contrasts between the lower and upper plates of the Roberts Mountains thrust, *in* Lageson, D.R., Peters, S.G., and Lahren, M.M., eds., Great Basin and Sierra Nevada: Geological Society of America Field Guide 2, Boulder, Colorado, p. 279–300.

Finney, S.C., and Perry, B.D., 1991, Depositional setting and paleogeography of Ordovician Vinini Formation, central Nevada, *in* Cooper, J.D., and Stephens, C.H., eds., Paleozoic paleogeography of the western United States—II: Los Angeles, California, Pacific Section Society Economic Paleontologists and Mineralogists, v. 67, p. 747–766.

Foulk, C.L., 1991, Geology, geochemistry and metal enrichments of the allochthonous siliceous assemblage rocks, central Tuscarora Mountains, Nevada [M.S. thesis]: Colorado School of Mines, Golden, 182 p.

Geslin, J.K., 1998, Distal ancestral Rocky Mountains tectonism: Evolution of the Pennsylvanian-Permian Oquirrh-Wood River basin, southern Idaho: Geological Society of America Bulletin, v. 110, no. 5, p. 644–663.

Gilluly, J., and Gates, O., 1965, Tectonic and igneous geology of the northern Shoshone Range, Nevada: U.S. Geological Survey Professional Paper 465, 153 p.

Harbaugh, D.W., and Dickinson, W.R., 1981, Depositional facies of Mississippian clastics, Antler foreland basin, central Diamond Mountains, Nevada: Journal of Sedimentary Petrology, v. 51, no. 4, p. 1,223–1,234.

Ketner, K.B., 1977, Deposition and deformation of lower Paleozoic western facies rocks, northern Nevada, *in* Stewart, J.H., Stevens, C.H., and Fritsche, A.E., eds., Paleozoic paleogeography of the western United States: Pacific Coast Paleogeography Symposium 1: Society of Economic Paleontologists and Mineralogists, Pacific Section, Los Angeles, p. 251–258.

Lopez-Blanco, M., Marzo, M., and Piña, J., 2000, Transgressive-regressive sequence hierarchy of foreland, fan-delta clastic wedges (Montserrat and Sant Llorenc del Munt, Middle Miocene, Ebro Basin, NE Spain): Sedimentary Geology, v. 138, p. 41–69.

McFarlane, M.J., 1997, The Roberts Mountains thrust in the northern Snake Mountains, Elko County, Nevada, *in* Perry, A.J., and Abbott, E.W., eds., The Roberts Mountains thrust, Elko and Eureka Counties, Nevada: Nevada Petroleum Society, 1997 Field Trip Guidebook, p. 17–34.

Merriam, C.W., and Anderson, C.A., 1942, Reconnaissance survey of the Roberts Mountains, Nevada: Geological Society of America Bulletin, v. 53, p. 1,675–1,728.

Moore, S., ed., 2002, Geology of the northern Carlin trend [map], *in* Thompson, T.B., Teal, Lewis, and Meeuwig, R.O., eds., Gold deposits of the Carlin trend: Nevada Bureau of Mines and Geology Bulletin 111, plate 1, 1:24,000.

Noble, P.J., 2000, Revised stratigraphy and structural relationships in the Roberts Mountains allochthon of Nevada (USA) based on radiolarian cherts, *in* Cluer, J.K., Price, J.G., Struhsacker, E.M., Hardyman, R.D., and Morris, C.L., eds., Geology and ore deposits 2000: The Great Basin and beyond: Reno, Nevada, Geological Society of Nevada, Symposium Proceedings, p. 439–449.

Noble, P.J., Ketner, K.B., and McClellan, W., 1997, Early Silurian radiolaria from northern Nevada: Marine Micropaleontology, v. 30, p. 215–223.

Oldow, J.S., Bally, A.W., Avé Lallemant, H.G., and Leeman, W.P., 1989, Phanerozoic evolution of the North American Cordillera; United States and Canada, *in* Bally, A.W., and Palmer, A.R., eds., The geology of North America—An overview: Geological Society of America, The Geology of North America, v. A, p. 139–232.

Papke, K.G., 1984, Barite in Nevada: Nevada Bureau of Mines and Geology Bulletin 98, 125 p.

Peters, S.G., 1998, Evidence for the Crescent Valley-Independence Lineament, north-central, Nevada, *in* Tosdal, R.M., ed., Contributions to the gold metallogeny of northern Nevada: U.S. Geological Survey Open-File Report 98-338, p. 106–118.

Peters, S.G., 2000, Regional- and district-scale dissolution, deformation, and fluid flow in sedimentary rock-hosted Au deposits of northern Nevada, *in* Cluer, J.K., Price, J.G., Struhsacker, E.M., Hardyman, R.D., and Morris, C.L., eds., Geology and ore deposits 2000: The Great Basin and beyond: Reno, Nevada, Geological Society of Nevada, Symposium Proceedings, p. 661–681.

Peters, S.G., 2003, Geologic map of the Bobs Flat Quadrangle, Eureka County, Nevada: Nevada Bureau of Mines and Geology Map 138, 13 p., 1:24,000.

Price, R.A., 1973, Large-scale gravitational flow of supracrustal rocks, southern Canadian Rockies, *in* DeJong, K.A., and Scholten, R., eds., Gravity and tectonics: Wiley, New York, p. 491–502.

Regnier, J., 1960, Cenozoic geology in the vicinity of Carlin, Nevada: Geological Society of America Bulletin, v. 71, no. 8, p. 1,191–1,199.

Roberts, R.J., 1964, Stratigraphy and structure of the Antler Peak Quadrangle, Humboldt and Lander Counties, Nevada: U.S. Geological Survey Professional Paper 459-A, 93 p.

Roberts, R.J., Crittenden, M.D., Jr., Tooker, E.W., Morris, H.T., Hose, R.K., and Cheney, T.M., 1965, Pennsylvanian and Permian basins in northwestern Utah, northeastern Nevada, and south-central Idaho: American Association of Petroleum Geologists Bulletin, v. 49, p. 1,926–1,956.

Roberts, R.J., Hotz, P.E., Gilluly, J., and Ferguson, H.G., 1958, Paleozoic rocks in north-central Nevada: American Association of Petroleum Geologists Bulletin, v. 42, no. 12, p. 2,813–2,857.

Sandberg, C.A., Gutschick, R.C., Johnson, J.G., Poole, F.G., and Sando, W.J., 1982, Middle Devonian to Late Mississippian geologic history of the overthrust belt region, western United States, *in* Powers, R.B., ed., Geologic studies of the Cordilleran thrust belt: Denver, Colorado, Rocky Mountain Association of Geologists, p. 691–719.

Saucier, A.E., 1997, The Antler thrust system in northern Nevada, *in* Perry, A.J., and Abbott, E.W., eds., The Roberts Mountains thrust, Elko and Eureka Counties, Nevada: Nevada Petroleum Society, 1997 Field Trip Guidebook, p. 1–16.

Silberling, N.J., and Roberts, R.J., 1962, Pre-Tertiary stratigraphy and structure of northwestern Nevada: Geological Society of America Special Paper 72, 58 p.

Snyder, W.S., Trexler, J.H., Jr., Cashman, P.H., Schlappa, T.A., and Davydov, V.I., 2000, Tectonostratigraphic framework of the upper Paleozoic continental margin of Nevada and southeastern California, *in* Geology and ore deposits 2000: The Great Basin and beyond, Program with Abstracts, Geological Society of Nevada Symposium 2000, Reno/Sparks, May, 2000, p. 76–77.

Stevens, C.H., and Stone, P., 1988, Early Permian thrust faults in east-central California: Geological Society of America Bulletin, v. 100, p. 522–562.

Theodore, T.G., Armstrong, A.K., Harris, A.G., Stevens, C.H., and Tosdal, R.M., 1998, Geology of the northern terminus of the Carlin trend, Nevada: Links between crustal shortening during the late Paleozoic Humboldt orogeny and northeast-striking faults, *in* Tosdal, R.M., ed., Contributions to the gold metallogeny of northern Nevada: U.S. Geological Survey Open-File Report 98-338, p. 69–105.

Theodore, T.G., Berger, V.I., and Singer, D.A., 2003, Synorogenic relations of the Pennsylvanian and Permian Strathearn Formation, *with a section on* Microfossil control on age of the Strathearn Formation by A.G. Harris and C.H. Stevens: Sedimentary Geology (in press).

Theodore, T.G., Kotlyar, B.B., Berger, V.I., Moring, B.C., and Singer, D.A., 2000a, Implications of stream-sediment geochemistry in the northern Carlin trend, Nevada, *in* Cluer, J.K., Price, J.G., Struhsacker, E.M., Hardyman, R.F., and Morris, C.L., eds, Geology and ore deposits 2000: The Great Basin and beyond: Geological Society of Nevada Symposium Proceedings, p. 929–958.

Theodore, T.G., Kotlyar, B.B., Singer, D.A., Berger, V.I., Moring, B.C., and Cluer, J.K., 2000b, Rock geochemistry in the Tuscarora Mountains, northern Carlin trend, Nevada: U.S. Geological Survey Open-File Report 00-402, 125 p.

Trexler, J.H., Jr., and Giles, K., 2000, The Antler orogeny in the Great Basin: A review of the data [abs.]: Geological Society of America Abstracts with Programs, v. 32, no. 7, p. A-382.

Ye, H., Royden, L., Burchfiel, C., and Schuepbach, M., 1996, Late Paleozoic deformation of interior North America: The greater ancestral Rocky Mountains: American Association of Petroleum Geologists, v. 80, no. 9, p. 1,397–1,432.