Golconda Summit, Nevada

Golconda Summit, I-80. Above highway where trucks are, Cambrian Preble Frm (phyllitic shale) under Antler Peak Is, Penn-Perm reef Is—juxtaposed on Iron Point fault (thrust on old maps, LANF in Cashman et al). Edna Mtn (Permian ss) at very top of hill. Small hill at right has Iron Point Thrust again within it. To left of highway, peak with antennae is Golconda Summit, which is Penn shale+chert of upper plate of Golconda allochthon. Ledge 1/3 way up is Antler Peak Is with brown Edna Mtn Frm above. Most of gray slopes behind is greenstone unit (basalts–andesites of Penn age) of upper plate of Golconda.
Golconda Summit, I80. Above highway where trucks are, Cambrian Preble Frm (phyllitic shale) under Antler Peak is, Penn-Perm reef is—juxtaposed on Iron Point fault (thrust on old maps, LANF in Cashman et al). Edna Mtn (Permian ss) at very top of hill. Small hill at right has Iron Point Thrust again within it. To left of highway, peak with antennae is Golconda Summit, which is Penn shale+chert of upper plate of Golconda allochthon. Ledge 1/3 way up is Antler Peak Is with brown Edna Mtn Frm above. Most of gray slopes behind is greenstone unit (basalts–andesites of Penn age) of upper plate of Golconda.
Figure 1.4. View of Hoffman Canyon and China Mountain in the Tobin Range, which is the type locality of the Sonoma Orogeny. Ferguson et al. (1952) noticed that the undeformed Koipato Formation rests on top of the highly deformed Golconda Allochthon with a marked angular unconformity. View to the north. Modified from Walter Snyder (per. comm.).

Koipato late Triassic (possibly late Permian); high initial Sr and very negative eNd suggest this was on NAM crust when intruded/erupted.
Kind of funny map as a lot of things are Mz (batholiths, for instance, and fold-and-thrust extent)
Crafford notes lower plate pretty undeformed, but upper plate hammered—in places relatively undeformed Tr on top. Also discuss Nolan belt, which is defined by Crafford as having continental affinity but higher grade metamorphism and west-verging thrusting in pre–mid–Penn.
So was Golconda emplaced on continental margin? Solid dots are from overlapping volcanics which seem exceptionally continental in origin. [Ideally should compare with Klamath/Sierra arc rocks]
Figure 9. Mississippian to Early Triassic (325–245 Ma) tectonomagmatic relations across the intermountain region. Selected late Paleozoic depocenters: Oquirrh–Wood River basin (Geslin, 1998; Hintze and Kowallis, 2009); Keeler–Darwin–El Paso (K-D-EP) basin cluster (Stevens et al., 1997, 2005; Stevens and Stone, 2007). See Figure 1 for the states shown (boundaries distorted) and Figure 2 for the time span depicted.
Figure 9. Mississippian to Early Triassic (325–245 Ma) tectonomagmatic relations across the intermountain region. Selected late Paleozoic depocenters: Oquirrh–Wood River basin (Geslin, 1998; Hintze and Kowallis, 2009); Keeler–Darwin–El Paso (K–D–EP) basin cluster (Stevens et al., 1997, 2005; Stevens and Stone, 2007). See Figure 1 for the states shown (boundaries distorted) and Figure 2 for the time span depicted.
Couple strange things here. One is that subsidence is highest north of where GA is known. Another is that this is quite far out from the GA front. However, if this is foredeep (which some literature says doesn’t exist), this is both time and space control.

Figure 8. (Color online) Isopach map of the sedimentary thicknesses recorded for the PTU-Smithian interval, showing marked differences in sedimentary thicknesses between northern and southern Sonoma Foreland Basin. The studied sections are shown at their paleolocation (Fig. 7). The reconstructed Golconda Allochthon Thrust Front during the PTU-Smithian studied interval is also indicated (modified from Dickinson, 2013; see also Fig. 12). The position of the wedge–top is based on variations in the sedimentary thicknesses and on geophysical data (Fig. 10).
Tectonic subsidence curves in the south...not too much. HAs that convex-up shape like foredeep with a moving load.
Tectonic subsidence curves in the north—lots more (unclear how this progressed, though)
A-A' is through the deeper foredeep, B-B' to the south. On a simple note, seems the forebulge should be a lot farther west in A-A' than B-B'. GA is Golconda Allochthon, GCB Grouse Creek Block, WT Wyoming craton, MT Mojave terrain.
...But their numerical analysis suggests that the complex variation of strength could make this work (FT is Farmington Terrane, thought to be Mesoproterozoic and weak (30km Te), other areas older and stiffer (90km Te)). Load edge is brown line and is constant within that boundary.

Figure 13. (Colour online) Numerical model of the SFB after the reconstructed palaeogeography and terranes map (cf. Figs 11, 12) with an heterogeneous basement ('strong' v. 'thermally attenuated weak' lithospheres) and an heterogeneous allochthon (recessed area in central part of the front). (a) Simulated map of the SFB. Thin black lines indicate the position of the 2D profiles; red lines indicate limits of the basement terranes (cf. Fig 10d). (b) 2D W–E profile of the northern part of the SFB model. The narrow foredeep is emplaced upon the 'thermally attenuated weak' FT and is bordered by a well expressed forebulge. (c) 2D W–E profile of the southern part of the SFB model. The wider foredeep is emplaced upon the 'strong' MT, and is bordered by a barely expressed forebulge. (d) 2D S–N profile of the SFB model. The two northern and southern parts of the basin are individualized with a limit near the MT/FT boundary.
Note C2 at right is main episode of Antler. Note too how frequent igneous rocks are, and of different ages.
sandstone interbeds. The Trenton unit is composed mainly of chert and shale. In other exposures of the Havallah sequence, the uppermost unit is the Mill Canyon Member, which includes interbedded turbidites, chert, and shale (Miller et al., 1982). Sandstones from the Middle Pennsylvanian–Lower Permian Jory unit and the Lower Permian Pumpernickel unit were analyzed during this study (Fig. 4).

In general, the monotonous lithology and structural complexity of the Havallah and Schoonover sequences preclude a full understanding of the structure of the Golconda allochthon. Both units are multiply deformed in most exposures, and structures include boudins, mullions, and open to tight folds. During progressive deformation of the Golconda allochthon, bedding was disrupted and thrust faults imbricated all rock types. According to a number of workers (e.g., Miller et al., 1982; Snyder and Brueckner, 1983; Babaie, 1987), a significant amount of the deformation occurred prior to emplacement of the allochthon onto the continental margin, as the subjacent autochthon is not as pervasively deformed as the Golconda allochthon.

A first-order problem in Cordilleran tectonics concerns the pre-emplacement position of the Golconda allochthon with respect to nearby terranes as well as North America. One model suggests that strata of the Golconda allochthon were deposited in a relatively wide basin and were subsequently incorporated into an accretionary prism built along the inboard margin of a magmatic arc that faced eastward, or toward the North American continent (Speed, 1979; Schweickert and Snyder, 1981; Speed and Sleep, 1982; Snyder and Brueckner, 1983; Dickinson et al., 1983; Brueckner and Snyder, 1985; Babaie, 1987). An opposing view asserts that the strata were deposited within a relatively narrow basin separating the North American margin from an outboard, west-facing magmatic arc (Burchfiel and Davis, 1972, 1975; Silberling, 1973; Miller et al., 1984, 1992; Harwood and Murchey, 1990; Burchfiel and Royden, 1991; Burchfiel et al., 1992). In addition, the possibility exists that strata within the allochthon accumulated a great distance from their present position and are far traveled (Coney et al., 1980).
Note C2 at right is main episode of Antler; C5 and C6 bound well dated thrusts in central NV. Note too how frequent igneous rocks are, and of different ages.
Schematic of the complexities found in both Antler and Golconda allochthons.
involved along with the Upper Paleozoic allochthons, but not when the Mesozoic strata are not present. It is emphasized here, as it was by Stahl (1989), that the extent of Mesozoic deformation within regions lacking Mesozoic rocks is difficult to assess. Clearly, Paleozoic rocks of both the Roberts Mountains and Golconda allochthons are involved in the Mesozoic shortening, and this deformation may have extended well east of the outcrop belt of Triassic and Jurassic rocks.

REVISED PALEOGEOGRAPHIC SCENARIOS

The discussions presented herein underscore the difficulty of developing a reasonable history for the paleogeography of the Havallah basin and the tectonics that created the Golconda allochthon and thrust. Was it truly a single basin, or is the Golconda allochthon an amalgamation of pieces from paleogeographically close, but different, settings? Was there a series of phases for the Havallah basin that included an early Late Devonian through earliest Pennsylvanian phase, a Late Pennsylvanian to largely Early Permian phase, and then a late Early to Middle Permian phase?

Two innovative approaches to interpreting the paleogeography and tectonics of the Havallah basin were presented by Tomlinson (1990) and Jones (1991). Tomlinson still supported late stage, back-arc thrusting to close the Havallah basin, but his new paleontologic and petrologic data forced him to invoke a more tectonically active basin, one tied to the continental margin to the east via clastic provenance, and sometimes to magmatic arc sources to the west. Jones (1991) reworked existing data and, coupled with her own studies, envisioned a paleogeographic setting where most of the Havallah basin was sufficiently distant from the continental margin to reflect open ocean, deeper-water environments and associated seamount development throughout the life of the basin. However, the eastern part of the basin bordered the continental margin and received recycled orogenic clastic sediment from a periodically reactivated Antler highlands. To explain this juxtaposition, Jones (1991) concluded that Havallah basin tectonostratigraphy reflected a long-lived, episodic, transpressive transform regime.

The first step in reconstructing the history of the Havallah basin is to envision the paleogeographic components of tectonostratigraphic units within the Golconda allochthon. Following our previous work (Snyder and Brueckner 1983, Brueckner and Snyder 1985), and that of Tomlinson (1990) and Jones (1991), as well as the scenarios presented by Miller et al. (1981, 1982, 1984, 1992), Babaie (1987), Murchey (1990), and Whiteford (1990), Figure 19 provides a composite snapshot of those components, but does not represent a depiction of the basin at any one time. The coordinates of Figure 19 are listed as W/NW to E/SE to reflect that the original configuration could have been oblique to the present-day orientation of the Golconda allochthon. The offshore arc-trench system, which could have been the Klamath–Northern Sierra arc terrane, is drawn as both a west- and east-facing arc. The west-facing arc could have been extant for most of the history of the basin, with the east-facing arc subsequently starting the closure of the basin. Conversely, the west-facing scenario may have existed for the entire life of the basin, with closure of a relatively narrow basin and the Sonoma orogeny being driven by back-arc thrusting. The Upper Paleozoic continental margin consisted of, from east to west, a shallow-water shelf, dominated by carbonate deposition, tectonically controlled basins in the Antler foreland (e.g., those of Fig. 3), and the Antler highland with the Antler overlap sequence deposited upon it. The carbonate–siliciclastic facies of the Golconda allochthon, reflecting continental North American source rocks, is depicted as having been deposited mainly on the eastern side of the Havallah basin, part of a rejuvenated Antler orogenic highland, where they were deposited on deformed, older Havallah basin units adjacent to the Antler orogenic belt. The volcaniclastic-lithic sandstone facies presumably was derived from the magmatic arc source terrane, and hence the majority of this lithofacies association would have been deposited in the western portion of the Havallah basin. Some of the older Late Devonian and Early Mississippian volcaniclastic debris could have been derived from ...
Timing: Devonian

- ARM: Shallow limestones
- Shelf: Carbonate shelf
- RMA: Slaven Chert
- Havallah Basin: initial deposits
- SE CA:
  - Sonora alloc.: Los Pazos Frm (turbidites etc)
Timing: Early Mississippian

- ARM: Leadville Is
- Shelf: Initial RMA debris
- RMA: erosion and deformation
- Havallah Basin: basalts, cherts
- SE CA: NE-trending shelf-slope facies belts
- Sonora alloc.: Unconformity
Timing: Middle Mississippian

- ARM: Leadville Is
- Shelf: Foreland basin and unconformity
- RMA: erosion and deformation
- Havallah Basin: basalts, cherts
- SE CA: Shelf deposits (NE trending facies)
- Sonora alloc.: Unconformity; start of orogeny
Timing: Late Mississippian

- ARM: Subsidence Oquirrh basin; minimal elsewhere
- Shelf: Antler overlap clastics
- RMA: erosion (and deformation?)
- Havallah Basin: cherts (mainly, +volcaniclastics)
- SE CA: Shelf deposits
- Sonora alloc.: Unconformity; orogenic deposits
Timing: Early Pennsylvanian

- ARM: Molas Frm, then initial orogenic deposits
- Shelf: Ely Is
- RMA: erosion, limited deposition
- Havallah Basin: cherts, several unconformities
- SE CA: Shelf deposits (Bird Spring Frm)-disruption NE?
- Sonora alloc.: Orogenic deposits
Timing: Middle Pennsylvanian

- ARM: Ancestral Rockies orogeny
- Shelf: Folds and thrusts
- RMA: erosion, limited deposition, deformation
- Havallah Basin: cherts, several unconformities
- SE CA: Keeler Basin (NNW trends; truncation fault?)
- Sonora alloc.: Orogenic deposits
Timing: Late Pennsylvanian

- ARM: Ancestral Rockies orogeny fading
- Shelf: Folds and thrusts
- RMA: erosion, limited deposition, deformation
- Havallah Basin: cherts, several unconformities
- SE CA: Keeler Basin, erosion (truncation fault?)
- Sonora alloc.: Orogenic deposits
Timing: Early Permian

- ARM: Ancestral Rockies orogeny fading
- Shelf: Folds and thrusts
- RMA: limestones, unconformities
- Havallah Basin: cherts, several unconformities, deep ls
- SE CA: Darwin Basin, Last Chance thrust
- Sonora alloc.: Orogenic deposits
Timing: Middle Permian

- ARM: Ancestral Rockies orogeny fading
- Shelf: quieter
- RMA: limited deposition
- Havallah Basin: limited deposition (likely deformation)
- SE CA: Subsidence, initial arc magmatism
- Sonora alloc.: unconformity
Timing: Late Permian

- ARM: Ancestral Rockies sinking in sediment
- Shelf: quieter
- RMA: Deformation (Sonoman orogeny?)
- Havallah Basin: deformation, emplaced as Golconda A.
- SE CA: rebounding elevation, arc magmatism
- Sonora alloc.: unconformity
implicating tectonism along the western, rather than southern, boundary of Laurentia (Sturmer et al. 2018). Detrital zircon studies identify the provenance of basin deposits, thus constraining the location of the basin at the time of deposition, with implications for subsequent tectonic translation (e.g., Gehrels et al. 2000; Linde et al. 2016, 2017; Lawton et al. 2017). Structures truncated by known unconformities record the kinematics and timing of subsequent deformation (e.g., McFarlane 1997, Trexler et al. 2004, Cashman et al. 2011). Such structural studies throughout Nevada document that the initiation of late Paleozoic (post-Antler) deformation in Nevada occurred in the middle Mississippian in the north and in the Early Permian in the south (Cashman et al. 2016) (Fig. 1).

This study focused on paradoxical geological relationships at Edna Mountain and concentrated in particular on its eastern flank, south of Iron Point. First, Ordovician units are exposed at Iron Point, whereas approximately 1 km to the west, Pennsylvanian rocks directly overlie the Cambrian Preble Formation (Erickson and Marsh 1974a) (Fig. 2). Second, analogous to this stratigraphic mismatch, several mapped structural features cannot be readily correlated to the Iron Point area from the rest of Edna Mountain. Several sets of structures, including folds of opposite vergence, were documented in maps and associated

Suggesting deformation was north to south [but there was stuff in SE CA]
Significance of Sonoman orogen: Seems to reflect the collapse of some marginal oceanic belt between Sierran–Klamath arc to west and Roberts Mtn stuff to east. But there seem to be issues at the early end of the spectrum...
Hosted the highly endemic fauna of the McCloud limestone (Ross and Ross, 1983; Stevens, 2009; Colpron et al., 2007), leading to the term McCloud arc. In Figure 14B, we present a paleogeographic-paleobathymetric model for the western terminus of the McCloud arc and the adjacent SW Cordillera passive margin, fashioned after the Scotia arc, South Sandwich transform, and adjacent back-arc region extending into the Antarctic passive margin (modified after the British Antarctic Survey, 1985). We depict the primary positions of the El Paso and Kernville terranes, and Shoo Fly complex in relation to the transform terminus of the McCloud arc, and to other early Paleozoic elements of the Cordillera, such as the primary position of the Roberts Mountain allochthon, the eastern Klamath arc terrane, and the Cordilleran passive margin. Early Paleozoic abyssal lithosphere of Panthalassa lay in a variety of positions in the offshore region, including that actively subducting beneath the McCloud arc, that trapped both in the forearc and back-arc basins of the arc, and that fixed along the initial rift-boundary transform system of the shelf edge. The principal transform that bounded the arc and partitioned Panthalassa lithosphere into subducting and fixed domains was the genesis site of the Foothills ophiolite belt. 

Offshore facies strata of the Roberts Mountains allochthon that appear correlative with the El Paso terrane were thrust onto part of the SW Cordilleran shelf, defining the early Mississippian Antler orogeny. Many workers have assumed that this “orogeny” was driven by a Devonian–Mississippian polarity reversal of the fringing arc. However, there is little more than the geometry of this isolated thrust belt to support this view. Alternatively, a failed attempt at spontaneous subduction initiation driven by sediment loading of aged Panthalassa lithosphere that formed proximal to the Cordilleran passive margin during its Neoproterozoic–Early Cambrian rift to drift phase is geodynamically highly plausible—given that such lithosphere was ~200 m.y. in age and highly loaded by Antler time. We again draw attention to the importance of highly aged Panthalassa lithosphere lying in vast regions offshore of the Cordilleran margin through Paleozoic and into early Mesozoic time.