Supplemental File S4. Detailed Structural Synthesis

This supplementary file contains a detailed description of structural information and timing constraints compiled from mid-Cretaceous structural features across the central Sierra Nevada. This supplement should be cited as the paper which it accompanies:

Attia, S., Paterson, S.R., Jiang, D., and Miller, R.B., 2022, Spatiotemporally heterogeneous deformation, indirect tectonomagmatic links, and lithospheric evolution during orogenic activity coeval with an arc flare-up: Geosphere, v. 18, <https://doi.org/10.1130/GES02478.1>.

**MAGMATIC FOLIATION**

**Yosemite Valley Intrusive Suite**

Plutons comprising the Early Cretaceous Yosemite Valley intrusive suite are found across a wide swath of axial CSN, forming two distinct domains that are separated by younger Late Cretaceous intrusions (Fig. 9; Bateman, 1992). Throughgoing, time-transgressive magmatic foliations throughout the constituent members of the Yosemite Valley intrusive suite are subvertical and strike to the northwest, with the exception of the area near Mount Hoffman (Figs. 1, 9) where magmatic foliations subparallel to the nearby Mount Hoffman shear zone show northeast-southwest trends (McFarlan, 2007; Johnson, 2013; Van Dyne, 2014). Geochronology analyses on plutonic rocks of the Yosemite Valley intrusive suite have yielded ca. 107 to 102 Ma interpreted crystallization ages (Ratajeski et al., 2001; Taylor, 2004; Putnam et al., 2015; Scheland et al., 2018, 2019), with one slightly older ~110 Ma presented by Ardill et al. (2018) and two anomalously young ages ca. 97-96 Ma reported by Stern et al. (1981). Given the widespread extent and number of reliable zircon U-Pb ages from the Yosemite Valley intrusive suite, the 107-102 Ma range of crystallization ages likely corresponds to the timespan of pluton construction over which these tectonically significant magmatic foliations may have developed.

**Buena Vista Crest Intrusive Suite**

Plutons comprising the Buena Vista Crest intrusive suite are exposed in the axial CSN, intruding the eastern margin of the southern Yosemite Valley intrusive suite (Fig. 9; Bateman, 1992). Throughgoing, time-transgressive magmatic foliations show consistent subvertical dips and north-northwest strikes throughout the main phases of the Buena Vista Crest intrusive suite (McFarlan, 2007). Interpreted rock ages from the Buena Vista Crest intrusive suite based on high-precision TIMS and LA-ICPMS span ~104-102 Ma (Putnam et al., 2015; Ardill et al., 2018). U-Pb geochronology analyses of multigrain zircon fractions presented by Stern et al. (1981) and Tobisch et al. (1995), show somewhat younger ca. 100 and 99 Ma crystallization ages. We exclude one anomalously old ca. 112 Ma rock age presented by Stern et al. (1981). Given the uncertainty in the younger limit of the timespan of Buena Vista Crest intrusive suite construction, these tectonically significant magmatic foliations formed anytime between ca. 104-99 Ma. (Fig. 8).

**Shellenbarger Pluton**

The latest Early Cretaceous Shellenbarger pluton intrudes deposits of the Minarets caldera exposed in the center of the Ritter Range pendant (Huber and Rinehart, 1965; Fiske and Tobisch, 1994). The Shellenbarger pluton displays a consistent magmatic foliation throughgoing across internal textural boundaries that dips 78 degrees towards 027 on average (Tomek et al., 2017). Zircon U-Pb geochronology analyses of the pluton have yielded ca. 101-100 Ma interpreted crystallization ages (Tomek et al., 2017). The surrounding wallrocks of the Minarets caldera have yielded interpreted rock ages of ca. 103-101 Ma (Attia et al., 2020), consistent with previous interpretations that the Shellenbarger pluton was emplaced shortly after caldera formation (Fiske and Tobisch, 1994). Given these timing constraints the tectonically significant magmatic foliation observed within this pluton formed ca. 101-100 Ma (Fig. 8).

**Tioga Pass Hypabyssal Complex**

A set of hypabyssal intrusions with textures ranging from aphanitic to porphyritic exposed at Tioga Pass (Fig. 1) have recently been reinterpreted as mid-Cretaceous in age (Ardill et al., 2020a; c.f. Schweickert and Lahren, 1999). The porphyritic to medium grained plutonic portions of this subvolcanic complex display a subvertical, southeast-striking, throughgoing magmatic foliation that dips 83 degrees towards 237 on average (Ardill et al., 2020a). Zircon U-Pb geochronology analyses spanning all intrusive units of the Tioga Pass complex yield interpreted crystallization ages ca. 101-99 Ma (Ardill et al., 2020a), constraining the formation of magmatic foliation to the same timespan (Fig. 8).

**Merced Peak Intrusive Suite**

The Merced Peak intrusive suite is mainly comprised of the Jackass Lake pluton and encloses several km-scale screens and pendants of Paleozoic, Jurassic, and mid-Cretaceous metamorphic strata in the axial to eastern CSN (Figs. 1, 9; Bateman, 1992; Yoshinobu et al., 2009; Pignotta et al., 2010). A subvertical to vertical, north-northwest striking magmatic foliation that is throughgoing and consistent across internal contacts between texturally and compositionally distinct phases of the Jackass Lakes pluton displays an average dip of 89 degrees towards 068 (Pignotta et al., 2010; Krueger and Yoshinobu, 2018). Zircon U-Pb geochronology analyses of multigrain fractions have yielded interpreted crystallization ages of ca. 99-97 Ma (McNulty et al., 1996), with one anomalously young ca. 93 Ma age and one anomalously old ca. 107 Ma age reported by Stern et al. (1981) that are inconsistent with independent timing constraints. The Merced Peak intrusive suite is intruded along its southern margin by the northern lobe of the Mount Givens pluton, which displays ca. 96 Ma crystallization ages in proximal exposures, and is intruded along its northern margin by plutons of the Washburn Lake intrusive suite, which have yielded ca. 98-95 Ma crystallization ages (Peck, 1980; Stern et al., 1981; Tobisch et al., 1995; McNulty et al., 1996; Frazer et al., 2014). These timing constraints constrain the formation of tectonically significant magmatic foliations in the Merced Peak intrusive suite to have occurred between ~99 and 96 Ma (Fig. 8).

**Washburn Lake Intrusive Suite**

Plutons comprising the Washburn Lake intrusive suite are exposed in the axial to eastern CSN, forming two distinct domains that are separated by a lobe of the Tuolumne intrusive complex (Fig. 9; Bateman, 1992). Magmatic foliations in the Merced Peak intrusive suite show consistent subvertical-vertical dips and north-northwest strikes that average ~330 across its constituent phases (Peck, 1980; Pignotta et al., 2010). A new crystallization age determination presented herein of ca. 98 Ma (Fig. 3, Tbl. 1) is consistent with a ca. 98 Ma presented by Stern et al. (1981). Tobisch et al. (1995) present a slightly younger ca. 95 Ma crystallization age that is nonetheless permissible given independent age constraints (Fig. 5). Plutons of the Washburn Lake intrusive suite are observed to be younger than the ca. 99-97 Ma Merced peak intrusive suite at intrusive contacts but are intruded by minor sills and dikes associated with the ca. 95-92 Ma Kuna Crest phase of the Tuolumne intrusive complex (Peck, 1980). Thus, the range of crystallization ages from analyses of the Washburn Lake intrusive suite constrains the formation of magmatic foliations to the same ca. 98-95 Ma timespan (Fig. 8).

**Jack Main Canyon Intrusive Suite**

The Jack Main Canyon intrusive suite is comprised of a set of migrating nested plutons exposed in the axial CSN, to the north of Hetch Hetchy (Figs. 1, 9). A subvertical-vertical, northwest-trending magmatic foliation is throughgoing across internal fabrics and boundaries related to pluton construction, with an average orientation dipping 88 degrees towards 037 (Scheland et al., 2018, 2019). A suite of zircon U-Pb geochronology analyses provide a well constrained range of crystallization ages that span ca. 98-95 Ma (Ardill et al., 2018; Scheland et al., 2018, 2019), constraining the formation of magmatic foliation to the same timespan (Fig. 8).

**Soldier Lake Pluton**

The Soldier Lake pluton is a small intrusive body exposed in the eastern CSN, just east of the Tuolumne intrusive complex within the Saddlebag Lake pendant (Figs. 1, 9). Cao et al. (2015) documented two sets of mutually crosscutting, subvertical magmatic foliations within this pluton, one trending northwest-southeast with an average orientation of 75/046 and the other trending east-west with an average orientation of 86/182 (Fig. 9). High-precision TIMS analyses on single grains of zircon from a sample of the Soldier Lake pluton provide a 97.4 Ma crystallization age that constrains the timing of formation of magmatic foliations within this pluton to ca. 97 Ma (Mundil et al., 2004; Cao et al., 2015).

**Yosemite Creek Pluton**

The Yosemite Creek pluton is an elongate intrusive body exposed in the axial CSN (Fig. 9; Bateman, 1992). Steep to vertical magmatic foliations within the Yosemite Creek pluton generally trend northwest-southeast throughout the pluton (Johnson, 2013; Van Dyne, 2014). TIMS analyses on single grains of zircon from a sample of the Yosemite Creek pluton provide a ca. 97 Ma crystallization age (Burgess et al., 2009) that constrains the timing of formation of magmatic foliations within this pluton (Fig. 8).

**Sentinel Pluton**

The Sentinel pluton is exposed within the axial CSN, where it is intruded by the slightly younger Tuolumne intrusive complex (Fig. 9; Bateman, 1992). Steep to vertical magmatic foliations within the Yosemite Creek pluton generally trend northwest-southeast throughout the pluton (Petsche, 2008). Zircon U-Pb geochronology TIMS analyses provide two ca. 95 Ma interpreted crystallization ages on samples from the Sentinel pluton (Coleman and Glazner, 1997; Burgess et al., 2009), only slightly older than the oldest ages from the crosscutting Tuolumne intrusive complex. These timing constraints indicate that magmatic foliations within the Sentinel pluton formed ca. 95 Ma (Fig. 8).

**Tuolumne Intrusive Complex**

A set of large nested intrusions exposed in the eastern CSN form the Tuolumne intrusive complex (Fig. 9; Bateman, 1992). Two sets of subvertical-vertical, mutually crosscutting magmatic foliations with distinct orientations that transgress across internal fabrics and boundaries related to long-lived pluton construction have been observed within the Tuolumne intrusive complex (Zak et al., 2007). One set strikes north-northwest (~330) on average and the other strikes west-northwest (~290) on average (Zak et al., 2007; Cao et al., 2015; Ardill et al., 2020b). Zircon U-Pb geochronology results published over 40 years have clarified the long-lived construction of the Tuolumne intrusive complex with the most modern analyses providing interpreted crystallization ages spanning ca. 95-84 Ma across its constituent phases (Stern et al., 1981; Coleman and Glazner, 1997; Coleman et al., 2004; Burgess and Miller, 2008; Memeti et al., 2010a; Paterson et al., 2011, 2016; Chambers et al., 2020). The presence of the two sets of mutually crosscutting magmatic foliations in all phases of Tuolumne intrusive complex indicate that these fabrics likely formed through the ca. 95-84 Ma timespan of pluton construction (Fig. 8; Zak et al., 2007).

**Mono Creek Granite**

The Mono Creek granite is the youngest phase of the Late Cretaceous John Muir intrusive suite, forming an elongate pluton exposed in the eastern CSN where it intrudes metamorphic wallrock strata in the southernmost Ritter Range pendant and older surrounding plutons (Figs. 4, 9; Bateman, 1992). Magmatic foliations that transgress internal fabrics and structures related to pluton construction in the northernmost portions of the Mono Creek granite show consistent east-west trends and subvertical-vertical dips, with an average orientation of 89/189 (Fig. 4). Zircon U-Pb age analyses from the Mono Creek granite provide crystallization ages spanning ca. 88 to 84 Ma, excluding one anomalously young ca. 76 Ma crystallization age (Stern et al., 1981; Davis et al., 2012). These crystallization age constraints indicate that tectonically significant magmatic foliations formed within the Mono Creek granite sometime between ~88-84 Ma (Fig. 8).

**TILTED BEDDING AND SOLID-STATE FOLIATION IN CRETACEOUS STRATA**

**Iron Mountain Pendant**

The Iron Mountain pendant is one of the westernmost known exposures of Cretaceous strata in the CSN (Figs. 1, 7, 9). Zircon U-Pb geochronology analyses of metavolcanic strata in the Iron Mountain pendant, showing shallow to moderate dips to the southeast, provide an interpreted rock age of 119 +/- 2 Ma (Fig. 9; Ardill et al., 2018; Ardill, 2020). These strata are intruded by the 120 ± 2 Ma Star Lakes granodiorite and other coeval intrusions (Ardill et al., 2018). These timing constraints indicate that mid-Lower Cretaceous strata in the Iron Mountain pendant were tilted and transferred downwards to pluton emplacement levels ca. 120 Ma (Fig. 8), and thus did not experience significant deformation during the mid-Cretaceous tectonic episode discussed herein.

**Spiller Canyon**

Volcanogenic metasedimentary strata exposed in the Spiller Canyon area between the Tuolumne intrusive complex and Solider Lake pluton (Figs. 1, 4, 9) show steep to vertical bedding with northwest strikes as well as a subparallel penetrative foliation (Cao et al., 2015). Detrital zircon U-Pb geochronology analyses from these strata provide a ca. 117 Ma maximum depositional age (Cao et al., 2015). Tilted bedding and solid-state foliations in these strata are truncated by the 97.4 ± 0.4 Ma Soldier Lake pluton (Mundil et al., 2004; Cao et al., 2015) and ca. 88-84 Ma Cathedral Peak phase of the Tuolumne intrusive complex (Paterson et al., 2016). These timing constraints indicate that tilting and penetrative deformation of mid-Lower Cretaceous strata in Spiller Canyon occurred any time between ca. 117-97 Ma (Fig. 8).

**Cinko Lake**

Dominantly andesitic metavolcanic tuffs to breccias in the Cinko Lake area, in the westernmost portion of the northernmost Saddlebag Lake pendant, show steep to vertical bedding that strikes approximately northwest on average and solid-state foliations with an average orientation of ~84/051 (Figs. 1, 4, 9; Memeti et al., 2010b; Cao, 2016). These metavolcanic strata show zircon U-Pb sample ages between 108 ± 4 Ma to 103 ± 1 Ma and are intruded by the intruded by 101.8 ± 0.2 Ma Harriet Lake granodiorite (Thompson et al., 2007; Memeti et al., 2010b). Thus, tilting, penetrative deformation, and downward transfer of these strata occurred between ca. 103-102 Ma (Fig. 8).

**Sawmill Canyon**

Mid-Cretaceous metavolcanic strata exposed along the eastern margin of the Tuolumne intrusive complex between Tioga Pass and Saddlebag Lake show steeply dipping bedding that strikes to the north-northwest that are somewhat oblique to bedding and foliations in nearby Triassic-Jurassic strata (Figs. 1, 4, 9; Hartman et al., 2018). Zircon U-Pb geochronology analyses of these mid-Cretaceous strata yield interpreted rock ages of 109 ± 2 Ma and 95 ± 2 Ma (Ardill et al., 2020a). These strata are intruded by the Kuna Crest phase of the Tuolumne intrusive complex, which is locally dated to ca. 93.5 Ma (Coleman et al., 2004; Paterson et al., 2016), indicating that these strata underwent tilting and downward transfer to pluton emplacement levels ca. 109-94 Ma (Fig. 8).

**Minarets Caldera**

Uppermost Lower Cretaceous metavolcanic strata exposed in the axis of the Ritter Range pendant form deposits associated with the Minarets caldera (Fig. 4; Fiske and Tobisch, 1994). These deposits are comprised of rhyolitic ash flows and caldera collapse deposits with intermediate-mafic volcanic blocks (Fiske and Tobisch, 1978, 1994), which have yielded interpreted rock age of ca 103-101 Ma (Attia et al., 2020). These strata show predominantly gently dipping bedding with average orientation of ~25/240, except where they are rotated to steep dips near the Bench Canyon shear zone and along the eastern margin of the caldera deposits (Figs. 4, 5; Tobisch and Fiske, 1982; Fiske and Tobisch, 1994; McNulty, 1995; Tobisch et al., 2000; Tomek et al., 2017). Domainal solid-state foliations developed in Minarets caldera strata outside of the extent of the Bench Canyon shear zone show an average orientation of 70/232 (Fig. 4; Tobisch and Fiske, 1982; Tomek et al., 2017). Deposits of the Minarets caldera are intruded by the undeformed ca. 101-100 Ma Shellenbarger pluton (Tomek et al., 2017), the ca. 97-92 Ma northern lobe of the Mount Givens pluton (Tbl. 1; Stern et al., 1981; Tobisch et al., 1993, 1995; Frazer et al., 2014), and mafic hypabyssal intrusions interpreted as coeval with proximal hypabyssal intrusions dated to ca. 102-100 Ma (Figs. 4, 5; Tobisch et al., 2000). Thus, tilting and penetrative deformation of these strata occurred ca. 101-100 Ma (Fig. 8) with progressive downward transfer from the arc surface to hypabyssal intrusion emplacement depths to pluton emplacement levels occurring between ~101-97 Ma.

**Davis Lakes**

Metamorphic volcanic and sedimentary strata exposed in the area around Davis Lakes dated as uppermost Lower Cretaceous in age are bounded by plutonic rocks associated with the Tuolumne intrusive complex and the bounding fault of the Minarets caldera (Figs. 1, 4). These strata dip steeply to the northwest with an average orientation of 64/336 and exhibit subvertical solid-state foliations with an average orientation of 84/244 (Fig. 4). Interpreted rock ages of these strata span ca. 103-100 Ma, with one anomalously young age of 96 ± 1 Ma (Tbl. 1, Fig. 3). The mid-Cretaceous strata in the Davis Lakes area were juxtaposed with the Minarets caldera ca. 101-100 Ma and intruded by ca. 95-92 Ma marginal phases of the Tuolumne intrusive complex (Memeti et al., 2010a, in press; Paterson et al., 2016). These timing constraints indicate that these strata were tilted prior to juxtaposition with the Minarets caldera, with tilting and penetrative deformation occurring ca. 101-100 Ma (Fig. 8).

**Beartrap Lake**

Rhyolitic metatuffs exposed near Beartrap Lake in the northernmost Saddlebag Lake pendant, dated by zircon U-Pb geochronology to ca. 100 Ma, show subvertical bedding with an average orientation of 79/239 (Cao, 2016). These strata were intruded by a ca. 100 Ma porphyritic pluton, the ca. 97 Ma Long Canyon pluton, and the northernmost portions of the ca. 89-84 Ma Cathedral Peak phase of the Tuolumne intrusive complex (Memeti et al., 2010a; Cao, 2016). A solid-state foliation that is broadly subparallel to tilted bedding and is also developed within the broadly coeval porphyritic pluton shows an average orientation 85/245, but is truncated by the ca. 97 Ma Long Canyon pluton (Cao, 2016). The timing constraints provided by ages of crosscutting intrusions indicate that tilting, bedding subparallel foliation development, and downward transfer occurred ca. 100-97 Ma (Fig. 8).

**Jackass Lakes Pendants**

Lower to Upper Cretaceous metavolcanic rocks, dominantly dacitic to rhyolitic tuffs with subordinate clastic andesitic deposits, are exposed in several km-scale wallrock screens and small pendants associated with the Jackass Lakes pluton and other phases of the Merced Peak intrusive suite (Figs. 1, 9). Steeply inclined bedding and broadly parallel solid-state foliations show systematic variations in orientation between these pendants (Peck, 1980; Pignotta, 2006; Yoshinobu et al., 2009; Pignotta et al., 2010). In the Post Peak pendant, moderate to subvertical dipping bedding and subparallel solid-state foliations generally strike to the west-northwest (Fig. 9). In the Granite Creek pendant, steep to vertical bedding and subparallel solid-state foliations generally strike to the south-southwest or north-northwest, with an average orientation of 84/062 (Pignotta et al., 2010). Zircon U-Pb geochronology analyses from correlative strata in the Merced Peak and Strawberry Mine pendants have yielded ca. 102 and 100 Ma interpreted rock ages of metavolcanic rocks and a ca. 97 Ma maximum depositional ages from metasedimentary strata (Stern et al., 1981; Memeti et al., 2010b). Tilted bedding and solid-state foliations in the Jackass Lakes pendants are truncated by crosscutting intrusions of the ca. 99-97 Ma Merced Peak intrusive suite (Stern et al., 1981; McNulty et al., 1996; Yoshinobu et al., 2009; Pignotta et al., 2010). Tilting, penetrative deformation, and downward transfer of these mid-Cretaceous strata thus occurred ca. 100-97 Ma.

**SHEAR ZONES**

**Contractional Shear Zones**

***Toe Jam Lake***

The Toe Jam Lake shear zone is an ~300 m wide and >3 km long zone of steep to subvertical dipping, south-southeast striking mylonitic foliations and shears developed in the Early Cretaceous Bummers Flat granodiorite near Toe Jam Lake in the northern axial CSN (Figs. 1, 9; Leopold, 2016). Kinematic indicators including S-C fabrics and asymmetric porphyroclasts are consistent with reverse-sense shear (Leopold, 2016). The timing of activity along the Toe Jam Lake shear zone is constrained by the ca. 110 Ma age of the deformed Bummers Flat granodiorite and the ca. 96 Ma age of the nearby Kinney Lakes granodiorite (Leopold, 2016).

***Mount Hoffman***

The Mount Hoffman shear zone is a 1-2 km wide and > 5 km zone of steep to subvertical, northeast striking protomylonitic to ultramylonitic ductile shear zones developed in intrusions of the Yosemite Valley intrusive suite near Mount Hoffman, west of the Tuolumne intrusive suite (Figs. 1, 9; Johnson, 2013). Kinematic indicators are consistent with southeast side up, reverse-sense shear (Johnson, 2013). Ductile deformation associated with the Mount Hoffman shear zone is evident in several phases of the Yosemite Valley intrusive suite including the ca. 103 Ma Mount Hoffman granodiorite and the ca. 106-103 Ma El Capitan granite (Ratajeski et al., 2001; Johnson, 2013; Putnam et al., 2015). The ca. 107-103 Ma Taft granite and subunits of the El Capitan granite, both part of the Yosemite Valley intrusive suite, truncate mylonitic fabrics but are themselves deformed by minor ductile shear zones (Johnson, 2013; Van Dyne, 2014). The crosscutting relationships between different phases of the Yosemite Valley intrusive suite with broadly overlapping interpreted crystallization ages complicate interpretations of the timing constraints of shear zone activity. The ca. 97 Ma Yosemite Creek pluton (Burgess et al., 2009) intrudes across all of the phases of the Yosemite Valley intrusive suite and displays no solid-state deformation, providing a minimum timing constraint on activity along the Mount Hoffman shear zone (Van Dyne, 2014).

***Bench Canyon***

As described in detail above, the Bench Canyon shear zone is a steep dipping, south-southeast striking reverse-sense shear zone (Figs. 5, 9). Previous models of the history of the Bench Canyon shear zone proposed (McNulty, 1995) a mid-Cretaceous phase of extension based principally on correlations with the tectonic model of Tobisch et al (1986) for mid-Cretaceous time in the CSN. As subsequently noted by Tobisch et al. (2000), there exists no evidence that supports a mid-Cretaceous extensional episode. Constraints from field relationships combined with new and recently published geochronology indicate that the Bench Canyon shear zone accommodated intra-arc contraction ca. 102-96 Ma (Figs. 8, 9).

***Kaiser Peak***

The Kaiser Peak shear zone is an ~1 km wide and ~3 km long zone of steep to subvertical dipping, northwest-southeast trending solid-state foliations and discrete mylonitic shears developed in the Dinkey Creek pluton of the Shaver intrusive suite near Kaiser Peak in the axial CSN (Figs. 1, 9; Tobisch et al., 1995). Solid-state foliations and discrete mylonitic shears, which often occur as conjugate pairs, show an associated stretching lineation that plunges approximately down-dip (Tobisch et al., 1995). Kinematic indicators from mylonites are consistent with reverse-sense shear along both sets of conjugate shears (Tobisch et al., 1995). The timing of activity along the Kaiser Peak shear zone is constrained by the ca. 104-101 Ma age of the deformed Dinkey Creek pluton and the ca. 97-95 Ma ages of the proximal portions of the Mount Givens pluton, which truncates shear zone fabrics (Figs. 8, 9; Stern et al., 1981; Tobisch et al., 1993; Lackey et al., 2012; Frazer et al., 2014). We favor initiation of the shear zone after construction of the Dinkey Creek pluton ceased ca. 101 Ma as no shear-zone related fabrics show a transition from hypersolidus to solid-state development (Tobisch et al., 1995), but an earlier synmagmatic shear zone initiation timing cannot be excluded (Paterson and Tobisch, 1992).

***Quartz Mountain***

The Quartz Mountain shear zone is a 1-2 km wide and ~10 km long zone of steep to subvertical, north-northwest trending solid-state foliations and discrete mylonitic to ultramylonitic shears, both associated with an approximately down-dip stretching lineation, that are developed in the Shuteye Peak pluton and plutons of the Buena Vista Crest intrusive suite near Quartz Mountain in the axial CSN (Figs. 1, 9; Tong, 1994; Tobisch et al., 1995). Kinematic indicators from mylonites are consistent with reverse-sense shear along both sets of conjugate shears (Tobisch et al., 1995). The timing of activity along the Quartz Mountain shear zone is constrained by the ca. 104-99 Ma ages of deformed Buena Vista Crest intrusive suite plutons and the ca. 97-95 ages of the proximal portions of the Mount Givens pluton, which truncates shear zone fabrics (Stern et al., 1981; Tobisch et al., 1995; Putnam et al., 2015; Ardill et al., 2018). We favor initiation of the shear zone after construction of the Illilouette Creek phase of the Buena Vista Crest intrusive suite ceased ca. 100 Ma as no shear-zone related fabrics show a transition from hypersolidus to solid-state development (Tong, 1994), but an earlier synmagmatic shear zone initiation timing cannot be excluded (Paterson and Tobisch, 1992).

**Shear Zones With Uncertain Kinematics**

***Reversed Peak***

As described in detail above, the Reversed Peak shear zone is a subvertical, northwest-southeast trending zone of mylonitic fabrics and discrete ductile-brittle shears developed in the Late Cretaceous Aeolian Buttes pluton and Triassic Lee Vining Canyon granite near Grant Lake in the easternmost CSN (Figs. 1, 6, 9). Although the kinematics of this shear zone are uncertain, we herein speculate that it accommodated intra-arc contraction. The timing of activity along the Reversed Peak shear zone is constrained by the ca. 96 Ma ages of the deformed Aeolian Buttes granodiorite and the undeformed June Lake granite that overlap within error (Figs. 3, 6). This shear zone is particularly notable as it represents the easternmost known mid-Cretaceous shear zone in the CSN (Fig. 9).

***Courtright-Wishon***

The Courtright-Wishon shear zone is a ~1 km wide and ~10 km long zone of steep to subvertical, north-northwest trending solid-state foliations and mylonitic to ultramylonitic fabrics developed in plutons of the Shaver intrusive suite and metamorphic wallrock screens along the southwestern margin of the Mount Givens pluton near the Courtright Reservoir in the axial CSN (Figs. 1, 9; Bateman et al., 1984; Tobisch et al., 1993, 1995). Foliations within the shear zone display an associated stretching lineation that plunges just to the south of foliation dip directions (Tobisch et al., 1995). Sparse kinematic indicators are consistent with west-side down normal sense shear (Tobisch et al., 1993). On the other hand, folding and deformation of a dike synkinematic with late phases of shear zone activity are consistent with contractional deformation (Tobisch et al., 1995). The timing of activity along the Courtright-Wishon shear zone is constrained by the ca. 104-101 Ma age of the deformed Dinkey Creek pluton and the ca. 91 Ma age of the southern portion of the Mount Given pluton (Figs. 8, 9; Stern et al., 1981; Tobisch et al., 1993, 1995; Lackey et al., 2012; Frazer et al., 2014). Although the extensional nature of the Courtright-Wishon shear zone is unique among mid-Cretaceous shear zones in the CSN and the interpreted kinematics are open to debate due to contradictory field relationships and the need for more research, we herein tentatively follow previous interpretations of normal-sense kinematics (Tobisch et al., 1993, 1995).

**Dextral Transpressional Shear Zones**

***Sing Peak***

The Sing Peak shear zone is a zone of mylonitized metamorphic strata and solid-state to magmatic foliations developed in Jurassic and Cretaceous host rocks near Sing Peak and the intruding Late Cretaceous Jackass Lakes pluton in the axial CSN (Figs. 1, 9; Krueger and Yoshinobu, 2018). Mylonitic to magmatic foliations related to the Sing Peak shear zone show steep to subvertical dips to the east-northeast and west-southwest with associated moderately plunging mineral and stretching lineations (Krueger and Yoshinobu, 2018). Mid-Cretaceous metavolcanic strata within the shear zone display well-developed mylonitic foliations and are herein assigned a ca. 100 Ma age based on the ages of correlative strata in nearby pendants. Plutonic rocks display a gradation between parallel solid-state and magmatic foliations within the shear zone, indicative of synmagmatic shear. Kinematic indicators are consistent with dextral transpressional shear (Krueger and Yoshinobu, 2018). The timing of activity along the Sing Peak shear zone is constrained by the ca. 100 Ma age of strata correlative with those deformed within the shear zone and the ca. 99-97 Ma age of the synmagmatically deformed Jackass Lakes pluton of the Merced Peak intrusive suite (Stern et al., 1981; McNulty et al., 1996; Memeti et al., 2010b).

***Northern Sierra Crest***

The Sierra Crest shear zone system is a series of dextral transpressional shear zones defined by subvertical, north-northwest trending mylonitic fabrics exposed along the easternmost CSN (Figs. 1, 9; Tikoff and Greene, 1997). The northern portion of the Sierra Crest shear zone system deforms Mesozoic plutons and metamorphic strata in the Saddlebag Lake pendant and eastern portions of the Ritter Range pendant (Fig. 4). Although previously treated as a set of related but distinct shear zones (Greene and Schweickert, 1995; Tikoff and Greene, 1997; Tikoff et al., 2005; Horsman et al., 2008; Nadin et al., 2016), the northern portion of the Sierra Crest shear zone system forms a single continuous shear zone that is variably intruded by Late Cretaceous plutons from the southernmost Ritter Range pendant to its terminus in the northern Saddlebag Lake pendant. (Fig. 4; Cao, 2016). We herein refer to it as the northern continuation of the Sierra Crest shear zone. This continuity is obscured near Tioga Pass and Saddlebag Lake where the Tuolumne intrusive complex synkinematically intruded near the core of the shear zone, which was followed by continued synmagmatic deformation within the eastern margin of all phases of the ca. 95-84 Ma Tuolumne intrusive complex (Cao et al., 2015; Hartman et al., 2018; Ardill et al., 2020a). Thus, the northern Sierra Crest shear zone consist of apparently separate segments that are in fact continuous.

In the Ritter Range and Saddlebag Lake pendants, the northern Sierra Crest shear zone consists of multiple anastomosing, narrow, simple shear dominated strands with triclinic fabric symmetry, which are separated by broad, lenticular, pure shear dominated domains that are characterized by transposition of older fabrics, kinematic indicators with inconsistent shear sense, and symmetric chocolate-tablet boudinage and folding, (Greene and Schweickert, 1995; Jiang and Bentley, 2012). Mineral lineation, present in both domains, typically forms high angles to the vorticity-normal section with orientations varying from down-dip to horizontal, defining a full girdle along the transposition foliation (Jiang, 2014). Simple shear is generally localized in weaker rocks (i.e. metasediments, calc-silicates, rhyolites) but anastomosing ductile shears often crosscut lithologic contacts or terminate within units (Horsman et al., 2008). The core of the shear zone is centered on the Paleozoic-Mesozoic contact in the southern Ritter Range pendant and defines a poorly understood step-over across the northern Ritter Range pendant onto the boundary between Triassic and Jurassic strata, where it continues until terminating in the northern Saddlebag Lake pendant (Fig. 4; Greene and Schweickert, 1995; Cao et al., 2015). This boundary is proximal to the eastern margin of the Tuolumne intrusive complex (Cao et al., 2015). Although the northern Sierra Crest shear zone deforms each phase of the Tuolumne intrusive complex, the main shear strand remained localized within adjacent host rocks. Thus, the Tuolumne intrusive complex was likely more competent than nearby host rocks on the timescales of orogenic strain accumulation, despite ~10 million years of high temperature and melt-present conditions (Paterson et al., 2011, 2016).

Recent work by Cao et al. (2015), Hartman et al. (2018), and Ardill et al. (2020a) redefines the timing of activity along the northern Sierra Crest shear zone in the Saddlebag Lake pendant. This portion of the northern Sierra Crest shear zone initiated prior to the synkinematic intrusion of the Soldier Lake pluton ca. 97 Ma, which truncates shear zone related fabrics and displays subsequent solid-state to magmatic deformation within the shear zone (Cao et al., 2015; Cao, 2016). Ductile deformation continued until a ca. 82-80 Ma transition to a localized, brittle fault system superposed onto mylonitic fabrics (Cao et al., 2015; Hartman et al., 2018). Similar timing constraints are evident along the northern Sierra Crest shear zone in the Ritter Range pendant (Figs. 1, 4). The ca. 98 Ma synkinematic Rush Creek pluton truncates shear zone related fabrics along the western periphery of the Gem Lake segment of the Sierra Crest shear zone and displays subsequent syn- to post-magmatic deformation within the periphery of the shear zone (Bentley, 2004; Memeti et al., in press). Ar-Ar thermochronology analyses of hornblende and biotite in metamorphic wallrock strata within the Sierra Crest shear zone in the Ritter Range pendant yield ca. 82-80 Ma cooling ages that bracket the cessation of ductile shear along this portion of the shear zone (Sharp et al., 2000).