[PS]Pre-Luning-Fencemaker Metamorphism and Deformation in the Northern Sand Springs Range, Nevada*

Jacob Jarvis[1], Sean Czarnecki[1], and Joseph Satterfield[1]

Search and Discovery Article #41814 (2016)**
Posted June 13, 2016

*Adapted from poster presentation given at AAPG Southwest Section Convention, Southwest Strategies – Stay the Course, Abilene, Texas, April 9-12, 2016. Please refer to the closely related article by authors, Search and Discovery Article #41813 (2016)

[1]Angelo State University, San Angelo, TX, USA (jjarvis2@angelo.edu)

Abstract

A 1:8,000-scale geologic map of the northern Sand Springs Range (SSR) shows a pre-Luning Fencemaker deformation and metamorphic event. The Sand Springs Range is located within the Sierran Arc and the Luning Fencemaker Fold and Thrust Belt (LFTB). LFTB folds and faults deform D1 metamorphic tectonites that are cross cut by Basin and Range extensional strike-slip faults. Page (1964), Wilden and Speed (1974), and Satterfield (2005) previously mapped this area. Oldow (1983) and Wyld (2002) describe contrasting regional sequences of deformation phases. The northern SSR contains four metamorphic tectonite map units: foliated marble, andalusite schist, quartz-rich schist, and Triassic meta-quartz porphyry. Cretaceous granitoid plutons and sills and Tertiary rhyolite sills intrude tectonites. Tertiary basalt and interbedded ash flow tuff overlie tectonites. The SSR contains three phases of deformation, a syn-metamorphic event (D1) followed by two non-metamorphic folding and thrusting phases characteristic of the LFTB. D1 occurred after Triassic quartz porphyry intruded and before Cretaceous granitoids. D1 map-scale and outcrop-scale folds are typically tight to isoclinal, strike NE, and dip steeply to the SE. A map scale D1 antiform located in the SW portion of the map area folds quartz-rich schist and andalusite schist map units. S1 axial-planar foliations strike NE and dip moderately to steeply NW and SE. Metamorphic minerals present in D1 are garnet, biotite, and andalusite indicating lower amphibolite facies. Mapping is significant because pre-LFTB amphibolite facies metamorphism and deformation has not been described elsewhere in the LFTB and because D1 metamorphism and foliations have been attributed to forceful pluton emplacement. Work on this project was funded by a 2015 SW AAPG research grant.

Selected References

Oldow, J.S., 1983, Tectonic implications of a late Mesozoic fold and thrust belt in northwestern Nevada: Geology, v. 11/9, p. 542-546.

Willden, R., and R.C. Speed, 1974, Geology and mineral deposits of Churchill County, Nevada, Nevada Bureau of Mines and Geology, 95 p.

Wyld, S.J., 2002, Structural evolution of a Mesozoic backarc fold-and-thrust belt in the U.S. Cordillera: New evidence from northern Nevada: GSA Bulletin, v. 114, p. 1452–1468.

Pre-Luning-Fencemaker Metamorphism and Deformation in the Northern Sand Springs Range, Nevada

Jacob Jarvis, Sean Czarnecki, Joseph Satterfield, Department of Physics and Geosciences, Angelo State University

Objectives:

1) Create a 1:8000 scale map of a small portion of the San Springs Assemblage within the Luning-Fencemaker Fold and Thrust Belt
2) Collect fault-kinematic data on low-angle and high-angle faults
3) Describe and measure map-scale and outcrop-scale folds
4) Construct a grid of cross-sections over the map area
5) Create an updated sequence of events for the area that can be correlated to regional sequences
6) Correlate pre-LFTB metamorphism in the Northern Sand Springs Range and Northern Wassuk Range

Methods:

1) Mapped in the field for a two week period using a topography map, GPS, Brunton compass, and aerial photos
2) Made interpretations of geology using satellite imagery
3) Studied typical units in thin section with a petrographic microscope
4) Used data gathered in the field to create a tied grid of cross sections to project the three dimensional subsurface into two dimensions
5) Plotted data onto stereonets to better interpret fold orientations

Image showing the foliation within the foliated marble. Foliation defined by white and grey bands.

Image showing the foliation within the andalusite schist. Foliation is defined by the parting between foliation planes.

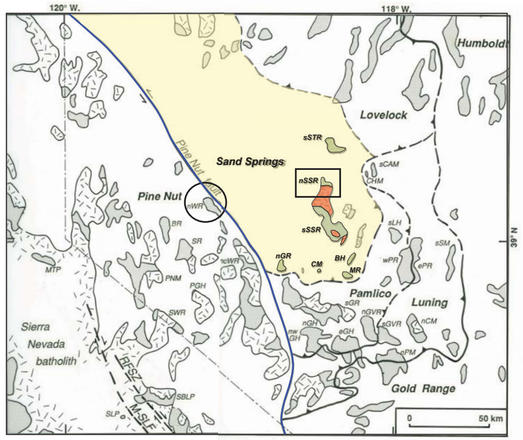
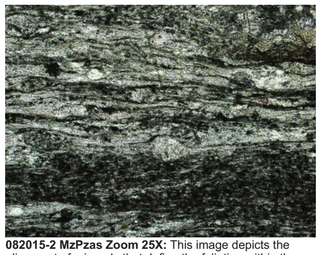


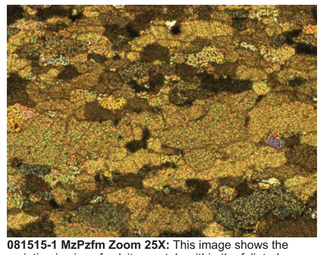
Image shows the regional location of the Sand Springs assemblage within the Luning-Fencemaker Fold and Thrust Belt (LFTB).

- The rectangle highlights the location of the Northern Sand Springs Range (nSSR) within the Sand Springs Assemblage.
- The circle highlights the location of the Northern Wassuk Range (nWR) within the Pine Nut Assemblage.
- The blue line highlights the Pine Nut Fault that generally acts as the boundary of Sierra Nevada related metamorphism.

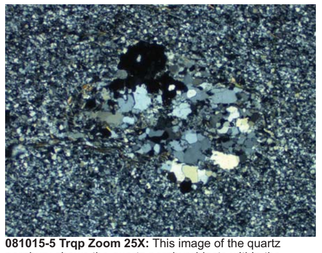
Thin Sections Showing Foliation Within the Metamorphic Units:



082015-2 MzPzas Zoom 25X: This image depicts the alignment of minerals that define the foliation within the Andalusite Schist.



081515-1 MzPzfm Zoom 25X: This image shows the variation in size of calcite crystals within the foliated marble that define the foliation. The larger crystals are seen in hand sample as the white bands and the smaller crystals are the grey bands.



081015-5 Trqp Zoom 25X: This image of the quartz porphyry shows the quartz porphyroblasts within the aphanitic matrix of quartz crystals.

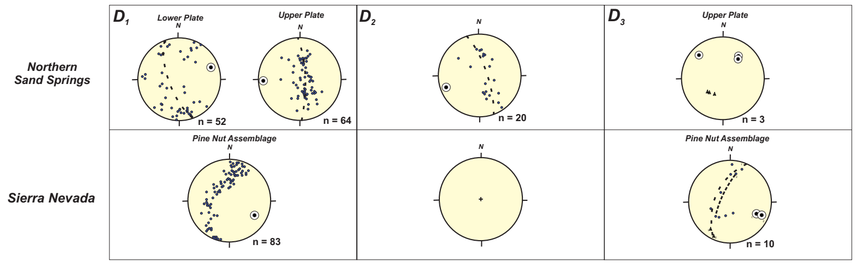
081915-5 MzPzqs Zoom 25X: This image shows a locally calcareous region of the quartz schist. The metamorphism in this unit is defined by the variation in crystal sizes.

Photo of Jacob Jarvis (foreground) and Sean Czarnecki (background) at the end of a long day taking measurements within the andalusite schist and along the thrust fault circling the middle klippe.

Conclusion:

- Three separate stages of deformation have been constrained within the Northern Sand Springs Range
- Timing constraints place deformation of the LFTB to be from mid-Jurassic to mid-Cretaceous
- D1 is a pre-LFTB syntectonic metamorphic event that is related to the NW trending D1 within the Sierra Nevada.
- D1 achieved amphibolite facies metamorphism that has not been previously documentated within the LFTB
- Typical metamorphism within the LFTB is subgreenschist or lower greenschist with NE trending S1 cleavage
- nSSR S1 foliation do not align perfectly with nWR S1 foliation due to overprinting of D2 in the nSSR and the absence of D2 in the nWR.

Stereonets Showing Deformation Phases and Related Folds and Foliations of The Northern Sand Springs Range and the Sierra Nevada



This figure shows three deformation events within the Luning-Fencemaker fold and thrust belt. S1 is a pre-LFTB Sierra Nevada related metamorphic foliation. As shown, D2 is not present within the Sierra Nevada and does not overprint S1. In the Sand Springs assemblage S1 is overprinted by D2 and D3 sequences. This accounts for the scatter in S1 measurements and the overall NE trending axial planes within S1. Since D2 is not present within the Sierra Nevada, axial planes within S1 follow the NW trend of D3.

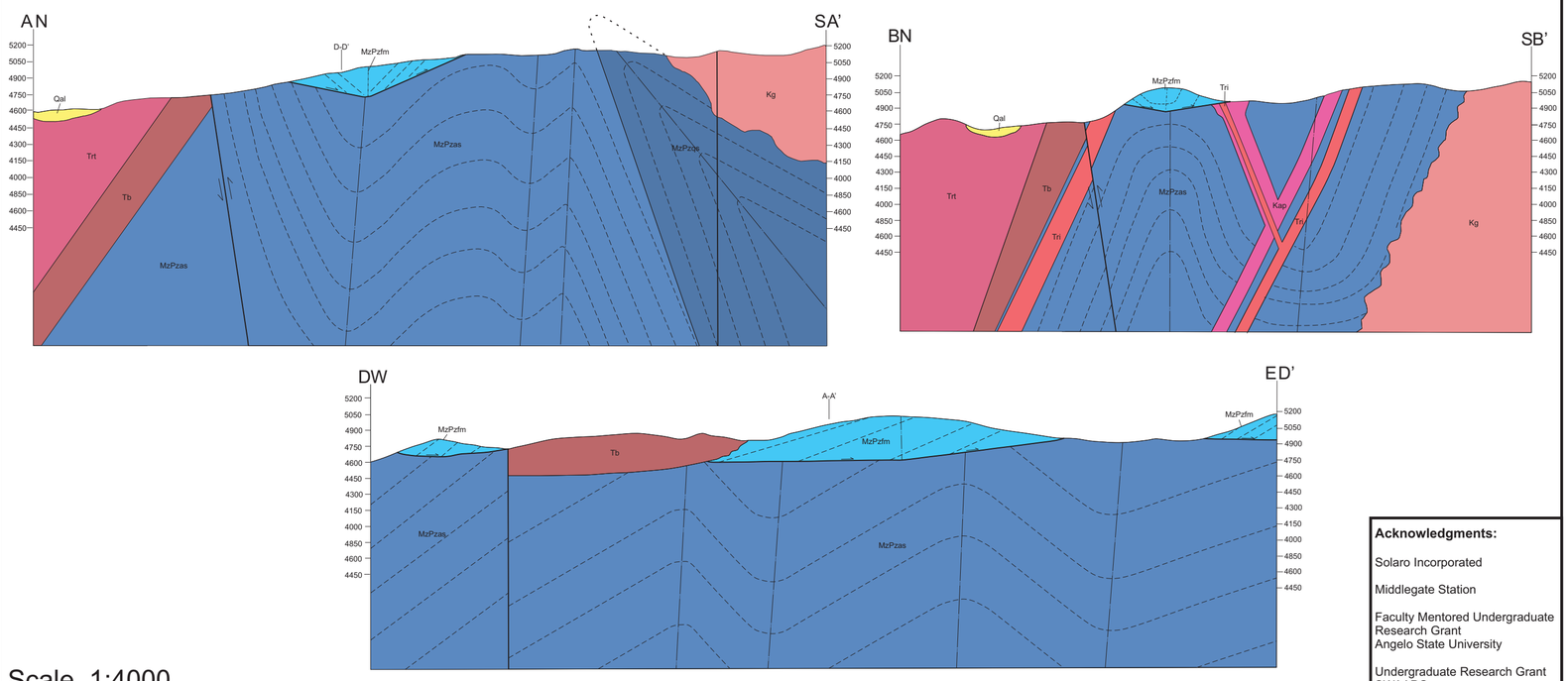
Field Pictures Representing D1-D3:

D1: This image shows outcrop scale D1 folds within S1 in the andalusite schist. D1 axial planes have an overall NW strike but have been highly altered by the following two LFTB deformation phases.

D2: This image shows the thrust fault of the eastern most klippe folded into a D2 map scale fold. D2 axial planes have an overall NE strike and plunge to the S-SW. This image was taken looking to the east from the middle klippe.

D3: This image shows the thrust fault of the western most klippe folded into a broad map scale D3 fold. D3 axial planes trend overall NW. This image was taken looking north from the south of the western most klippe.

Cross Sections:



Scale 1:4000

Acknowledgments:

Solaro Incorporated

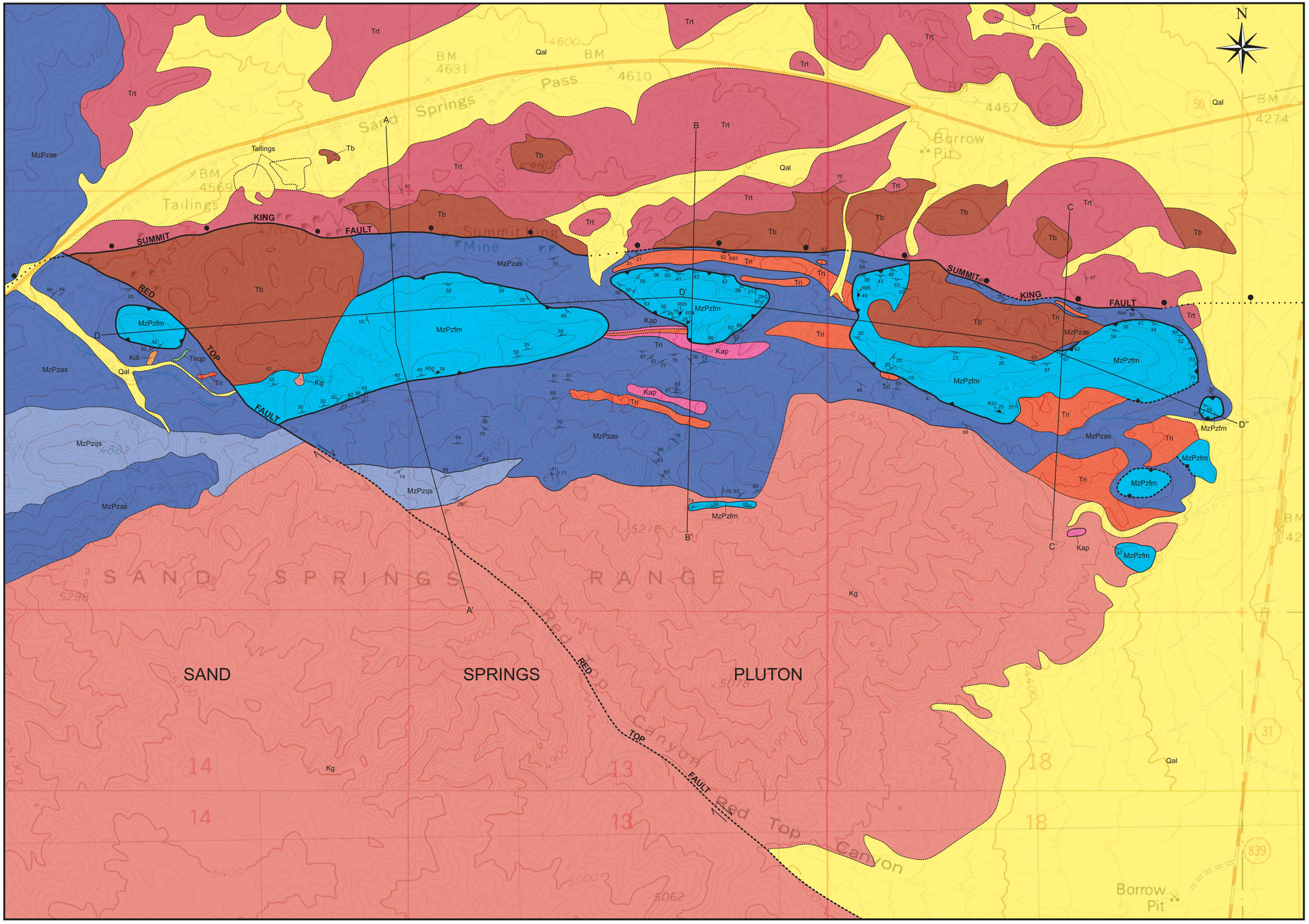
Middlegate Station

Faculty Mentored Undergraduate Research Grant
Angelo State University

Undergraduate Research Grant
SWAAPG

Geologic Map of the Northern Sand Springs Range, Churchill County, Nevada

Sean Czarnecki, Jacob Jarvis, and Joseph Satterfield
Department of Physics and Geosciences, Angelo State University April 2016



LEGEND

Quaternary

- Qal — **Quaternary alluvium.** Unconsolidated sand, gravel, and mud in active or recently active stream channels and alluvial fans mapped in relatively flat topographic lows using satellite imagery.

Tertiary

- Trt — **Tertiary rhylite tuff.** White rhyolite tuff which weathers gray. Contains 40% quartz and 50% albite mostly ≤ 1 mm but some large (0.5-2 0 cm) subhedral-euhedral crystals, and trace biotite and subhedral hornblende ≤ 2 mm. A highly fractured and friable slope-former which exhibits compaction foliation of 2-40 mm fiamme and is locally hydrothermally altered to a pale green color. Primarily exposed north of Summit King Fault.
- Tb — **Tertiary basalt.** Gray basalt which weathers dark brown, and contains 20-30% fishscale 0.5-5.0 mm albite crystals in an aphanitic mafic matrix. Cliff-former which is very resistant. Flow foliation evident locally.
- Tri — **Tertiary rhyolite intrusion.** White to cream and tan rhyolite. Contains 90% quartz crystals that are up to 0.35 mm in an aphanitic quartz matrix which also includes trace muscovite and plagioclase. Moderately resistant and slightly friable. Unit presents itself mostly as E-W trending sills or dikes but also as larger masses.

Cretaceous

- Kg — **Cretaceous granite.** White granite which weathers off-white to brown. Phaneritic crystals consisting of 35-45% ~4 mm quartz, 40% ~8 mm plagioclase, 0-16% ~8 mm hornblende, 8-10% ~5 mm biotite, and 1-5% muscovite, which are anhedral to subhedral. Highly resistant and flow foliation present locally. Primarily exposed as the Sand Springs Pluton.
- Kap — **Cretaceous aplite.** Grey to dark grey aplite, weathers cream to tan to brown. Minerals consist of ~60% 1-3 mm plagioclase, ~40% 1-3 mm quartz, and trace biotite. Highly resistant and non-friable. This unit is finer grained than other Cretaceous intrusions, and this is presumed to be due to its emplacement as shallow sills or dikes.
- Kdi — **Cretaceous diorite.** Grey to black diorite. Porphyritic with a matrix of 100% ~0.5 mm plagioclase (possibly anorthite) crystals. Porphyries are ~6 mm hornblende with some opaques. Highly resistant and non-friable. Unit is present as sills or dikes.

Triassic

- Trqp — **Triassic quartz porphyry.** White to cream to light tan quartz porphyry. Weathers grey to black and contains a metallic sheen on some surfaces. Matrix is nearly 100% quartz with ~3 mm quartz porphyries that constitute 5% of the unit with trace feldspar. Contains a penetrative metamorphic foliation, is lightly resistant, and weathers to a moderate slope former.

Mesozoic or Paleozoic

- MzPzfm — **Mesozoic or Paleozoic foliated marble.** White and gray foliated marble in which the foliation is defined by thin (1-4 mm), sometimes folded, white bands of thermally altered up to 3.0 mm calcite crystals within a gray matrix of 0.18-0.25 mm calcite crystals. Very firm cliff-former. Thermal alteration due to Cretaceous intrusions, Tertiary intrusions, and related hydrothermal activity locally obliterates foliation. Primarily exposed on klippen.
- MzPzas — **Mesozoic or Paleozoic andalusite schist.** Very dark-gray andalusite schist containing distinctive 5% by volume 0.5-1.0 mm andalusite crystals in an aphanitic matrix containing graphite, biotite, and quartz. Abundant graphite is from a carbon-rich shale protolith. Slope former which is highly friable when weathered. Remnant bedding seen locally (most often on west side of map area) and is evidenced by interbedded MzPzqs. Schistosity evidenced by fracturing into thin sheets.
- MzPzqs — **Mesozoic or Paleozoic quartz schist.** White to cream to light-brown quartz schist which weathers light-red to brown. Contains 98% 0.35-0.50 mm quartz crystals, and trace muscovite from an inferred quartz sandstone protolith. Slope former which is highly friable when weathered. Remnant bedding seen locally (most often on west side of map area), and schistosity is evidenced by fracturing into thin sheets. Interbedded with MzPzas and locally calcareous. Primarily exposed in distinct beds on western side of map area near Kg contact.

- 46 — **Strike and dip of original bedding (S_0)**
- 67 — **Strike and dip of compaction foliation (S_c)**
- 63 — **Strike and dip of metamorphic foliation (S_1)**
- R74 25 — **Strike and dip of fault surface, including rake of slickenlines (S_f)**
- **Contact**
- **Contact approximately located**
- **Strike-slip fault**
- **Strike-slip fault approximately located**
- **High angle fault, ball on downthrown side**
- **High angle fault approximately located, ball on downthrown side**
- **High angle fault covered, ball on downthrown side**
- **Thrust fault, teeth on upper plate**
- **Thrust fault approximately located, teeth on upper plate**

Scale 1:4000

0 0.25 0.5 0.75 1 Miles