Mesoproterozoic Rock Analysis in Northern Tusas Mountain Range, New Mexico

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Abstract:

Continents are made by the extraction of new igneous materials from the mantle, recycling of existing sedimentary materials, and tectonic accretion and imbrication of these materials into new crustal segments. Understanding the tectonic processes that control how this happens requires seeing how the strongest part of the crust, which is in the middle, (~12-16 km down) evolved over time during assembly. Proterozoic rocks of Northern New Mexico in general provide an opportunity to study how continental crust develops from the important perspective of the middle crust. Mesoproterozoic rocks of the Tusas Mountains preserve a succession of geologic events that include the initial development of island arc rocks, deposition of sediments and intrusion of granites, and two to three significant episodes of deformation that have been interpreted to record the assembly of the crust in this region. **Critically, the <u>typical</u> cross-cutting field relationships between the sediment and granites, and therefore assembly processing, are not clear. Assembly could have occurred very quickly, in ~20 Ma, or may have taken up to ~250 Ma.**

Research Question:

<u>"Does a contact metamorphism exist in the youngest metasedimentary unit?"</u>

Understanding the thermal structure of the Moppin Complex (oldest) and Ortega quartzite (youngest) at the time of granitic emplacement ~ 1.69 Ga. and to see if this structure appears in the neighboring metasediments can be done by comparing the textural relationships between minerals that preserve peak temperatures for these rocks to the ones that preserve deformational fabrics. If mineral patterns are similar, this means that the near by granitic plutons provide a certain date of tectonic assembly for this portion of northern New Mexico.

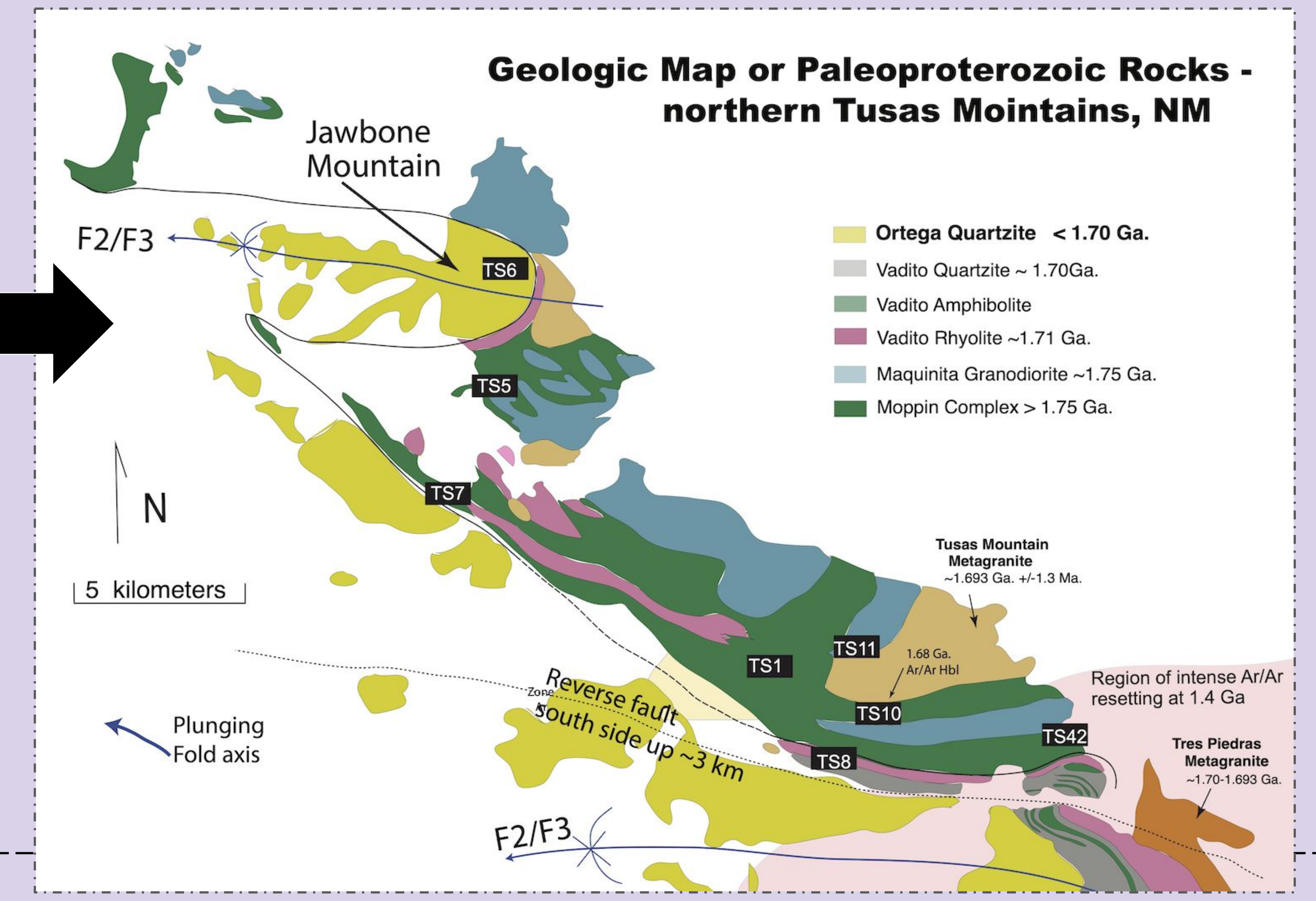
Background:

- Tusas Mountain Range displays metamorphic igneous and sedimentary rocks shown to record mid-crustal conditions (500˚C, 4-5kbars) and tectonic folds and fabrics associated with assembly of the southern margin of the Laurentian crust (Williams et al., 1999; Davis et al., 2012).
- <u>These lithologic units include</u>:
  - **Moppin Complex** *(oldest)*: metavolcanic and immature metasediment sequence, which are cross-cut by the Maquinita metagranidiorite at 1.75 Ga (Bauer, 1989).
  - **Vadito metarhyolite and Ortega quartzite** lie unconformably on the Moppin. Vadito dated to ~ 1.71 Ga. (Bauer, 1989).
  - **Tres Piedras and Tusas Mountain metagranites** intruded the Moppin at 1.69-1.70 Ga., however it is not clear that the Ortega had been deposited.
- <u>Intense reheating at 1.4 Ga</u> across much of the northern New Mexico region reset all dated Al-rich minerals that has erased evidence for older processes (Williams et al., 1999)
- <u>The Field Area of Jawbone Mountain</u> (see Figure 1) displays the contact between the Ortega Quartzite and the greenschists and amphibolites of the Moppin Complex (Bauer, 1989), that continue for several kilometers to the Tusas Mountain and Tres Piedras plutons. This region has been recently recognized to LACK the 1.4 Ga. thermal overprint.

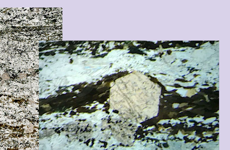
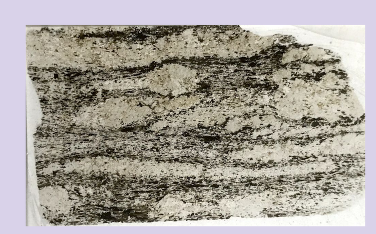
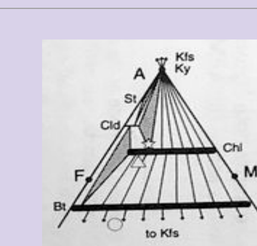
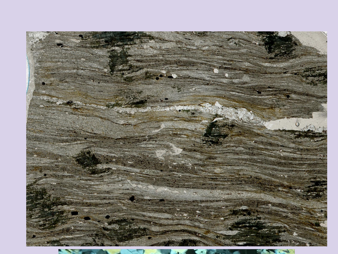
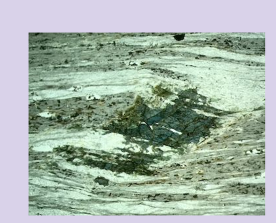
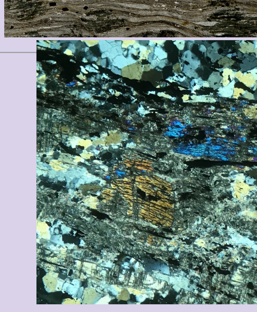
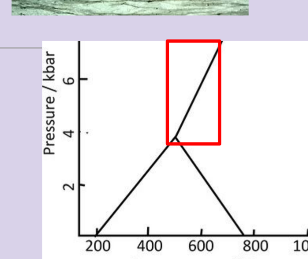
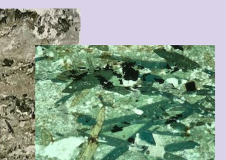
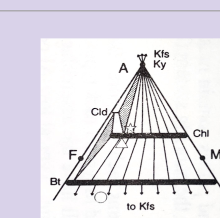
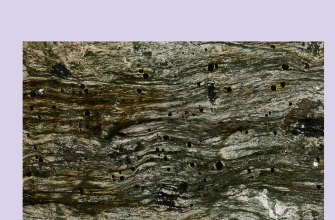
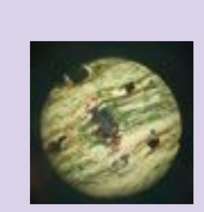
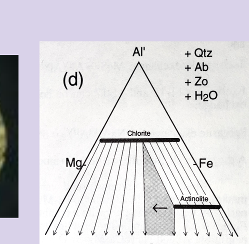
Methods:

1. Samples of pelitic compositions that surround the Tres Piedras and Tusas Mountain metagranites.
2. To analyze the microstructures of the rocks, thin sections were made from each sample.
3. An analyzation of each thin section was done using the Leica DM750P petrographic microscope to find more information about the deposition and deformation processes that have been kept in the outcrop samples.
4. AFM Chemographic projections in the KFMASH system (Spear, 2008) provide approximate temperature and pressure conditions for metamorphism of pelitic compositions. Observation of kyanite vs sillimanite pseudomorphs also provide data
5. AFM data was compared to estimations of elevated geothermal gradients (Williams and Karlstrom, 2010 and Spear et al., 1984.)
6. P&T condition for each thin-section sample were placed on a geologic map to reconstruct a gradient map around the pluton

Figure 1: Showing the underlying outcrop of the northern Tusas Mountain range with the 8 different TS sample locations spread throughout. The region of intense Ar- resetting by the Tres Piedras from 1.4 Ga is faintly highlighted in the southeast corner.



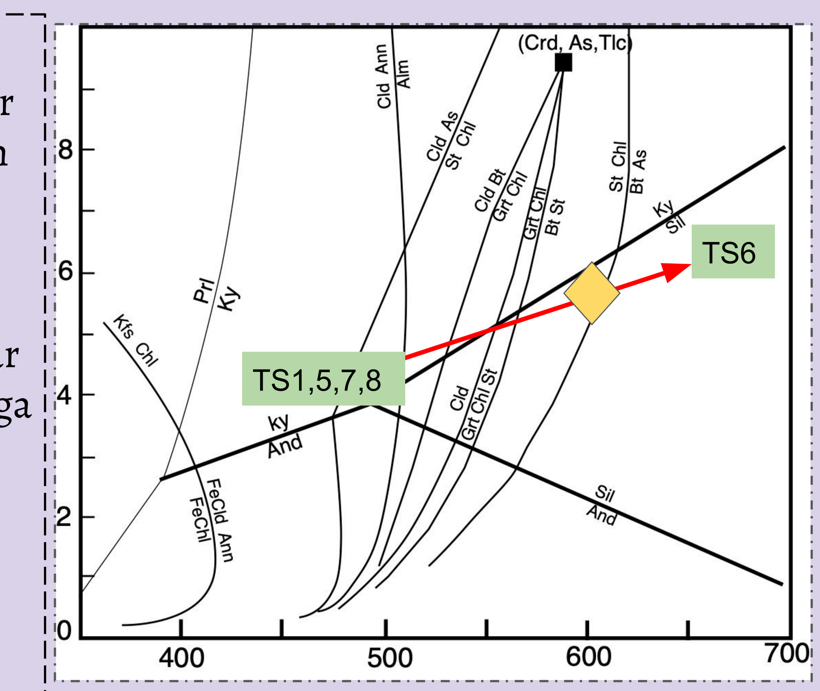
Results:

TS#	Distance from corresponding pluton	Photos ➔ Full Slide Photo ➔ Petrographic Microscope Photos	Interpretations (all bulk compositions include Ms+Qtz)
TS11	5 meters from pluton on north side of Tusas Mountain		**Grt+St+Bt**: inclusion trails in Grt are curved. No fabric wraps Grt, so thermal peak was after the last deformation.
TS10	~20 meters from contact on south side of Tusas Mountain	 	**Grt+Bt+Calc**: Grt has very sharp corners which shows initial low temp growth.
TS6	~20 meters from the western margin of the much larger Tres Piedras metagranite		**Bt (aligned), Ms (unaligned)+ Kfs:** Bt dark regions lack Al-rich phases, bulk comp may have lost Al during Ms driven partial melting. Ms+Ab occurs in lighter areas, which are likely zones of partial melt: so >700˚C
TS8	>300 meters south of Tusas Mountain Granite, *High-Al bulk*	 	**Cld+Chl+Ms**; ~475-500˚C, ~5-5.5 kbs (PERPLEX modeling Davis et al. 2010). Cld grew post a single simple deformational fabric
TS1	300 meters, west of Tusas Mountain, *High-Al bulk*	 	**Cld+Ms**; similar compositions to TS8, Strong deformational fabric. Intermediate pressure field with ~400˚C
TS42	>300 meters	 	**Ky->Sil:** Kyanite wrapped by Sillimanite (fibrolite variety, Polymorph reaction) which is not deformed. >575˚C
TS7	>300 meters, far away from any obvious heat. *High-Al bulk*	  	**Cld+Chl+Ms:** Chl is early, Cld is late ~4kbar and 460˚C, main assemblage is post-deformation
TS5	>300 meters, South of Jawbone, far from abvious heat, *High-Al bulk*	  	**Cld+Chl+Calc**+ pseudomorph: former dolomite? Chl aligned, Cld late, minor post Cld deformation .

Discussion:

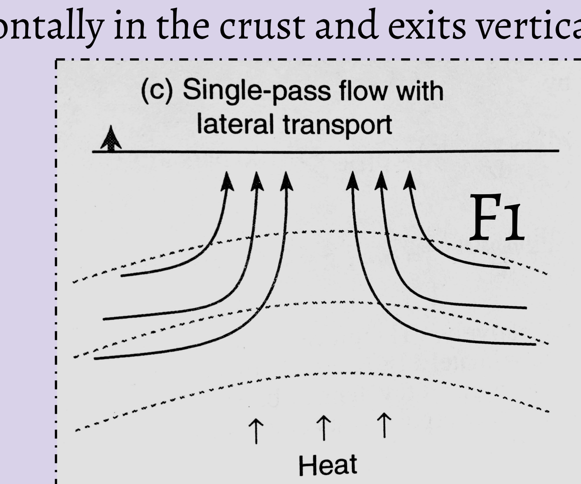
- Several samples showed similar bulk compositions which made interpretation more robust
- Phases of Chloritoid (Cld) + Muscovite (Ms), LACKING biotite that can be interpreted to be high alumina in compositions, therefore the minerals that grew were all above the Chlorite compositional line.
- <u>Pelitic AFM projections show</u>:
  - TS10, Chlorite and garnet grains grew at the expense of chloritoid on the way to high temperature. There is a tie line flip between the bulk compositions for sample TS 11: chloritoid + chlorite + garnet to chlorite + garnet + biotite (all assumed to also include quartz, muscovite, and H2O) when there is an increase in temperature.
  - High temperature pelitic rocks in this location (TS11, TS10, TS11, and TS6) show that conditions close to the pluton were at or above the wet muscovite granitic melt solidus (specifically TS6) .
  - As distance from the pluton increases, (TS8, TS1, TS42, TS7, TS5) the grade of metamorphism decreases.
  - Concluding with TS5 in the realm of low P and low T
  - So, background 'average' P-T conditions away from the plutons were ~450˚C and middle crustal pressures.
- TS 42 shows a localized elevation from the background conditions due to pseudomorph of Sillimanite on Kyanite. This shows that there was a heating spike when the Ortega quartzite was present.

Figure 2: Generalized PT reaction grid (Spear and Cheney, 1989) with samples placed on red line in temp context. Note increase of ~200˚C. The yellow star shows that TS42: Ortega quartzite has been affected by contact metamorphism, most likely from a small pluton mapped near Jawbone related to the 1.69 Ga. magmatism.



- The landscape was made from a single-pass fluid/heating flow, where the transport of fluid moves horizontally in the crust and exits vertically. (Figure 3)

Figure 3: Showing the motion of fluid in the crust.



Conclusions:

The background conditions in the Moppin Complex were ~450˚C, while the Ortega quartzite to the north, near a mapped granitic body, showed higher conditions, >550˚C, which could only have happened due to contact metamorphism around granitic plutons regionally ~1.69 Ga. during a single emplacement time.

References:

- Bauer, P. W. (1989) Stratigraphic nomenclature of proterozoic rocks, northern New Mexico- revisions, redefinitions, and formalization, New Mexico Geology, 11 (3), 45-52.
- Davis, P. and Kruckenberg, S. (2012), Integrating field, microstructures, magnetic fabrics, metamorphic studies to establish Yavapai-Mazatazal-aged syntectonic pluton emplacement and strain localization in the Tusas Mountains, New Mexico, AGU Fall Meeting Abstracts, 1.
- Williams, M. L., K. E. Karlstrom, A. Lanzirotti, A. S. Read, J. L. Bishop, C. E. Lombardi, J. N. Pedrick, and M. B. Wingsted (1999), New Mexico middle-crustal cross sections : 1.65-Ga macroscopic geometry, 1.4-Ga thermal structure, and continued problems in understanding crustal evolution, Rocky Mountain Geology, 34(1), 53-66.