Physical Properties of Pulverized Tejon Lookout Granite, San Andreas and Garlock Faults, Southern California, Based on XRF, XRD, and Particle Size Analysis

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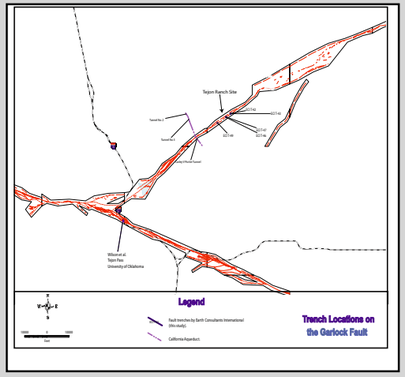
Abstract

We discuss laboratory analyses of samples of pulverized Tejon Lookout Granite from along the San Andreas fault at Tejon Pass and Garlock faults on Tejon Ranch. Each sample met the field criteria of pulverization; individual 1-2 mm-sized crystals can be recognized in the field but the granite can be disaggregated with finger pressure and exhibits the texture of toothpaste. XRF major and trace chemistry analyses demonstrate lack of significant chemical weathering for all samples, and the chemical index of alteration confirms this interpretation. This conclusion is supported by thin section analysis that shows intensely shattered crystal grains with little or no evidence of alteration near the fault core. XRD analysis, however, indicates that expandable clays dominate the <4micron fraction, which makes up less than 10% of the total sample. Particle size analyses show that most particles fall within the size range of 31micron to 500micron , and are much coarser than previously reported by B. Wilson and colleagues. We conducted extensive baseline tests on a Horiba LA930 laser particle size analyzer (similar to B. Wilson) and found that coarser particles fall out of suspension during extended runs but can be recovered by increasing the circulation speed. To avoid this and other problems associated with laser particle size analyzers, we also used the pipette method that allows for a complete discrimination of each particle class range. The spatial association of the observed pulverized rocks within the active fault cores implies that pulverization is the product of dynamic earthquake slip. Average grain sizes in the range we have observed may consume no more than ~1% of the earthquake energy released during rupture. The apparent lack of shear in thin sections of different orientations suggests that the grain size reduction is likely caused by tensional stress at the propagating rupture tip.

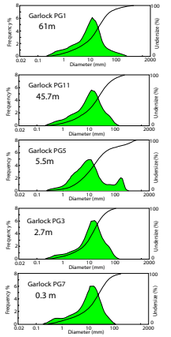
Study Area along the Garlock Fault at Tejon Ranch and along the San Andreas Fault at Tejon Pass



Particle Size Distribution Analysis

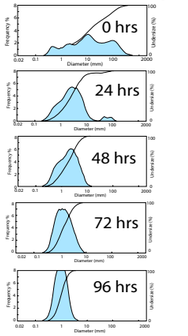
Horiba LA 930 Laser Paticle Size Analyzer

Garlock Fault at Tejon Ranch



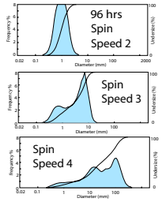
The results of particle size analysis using the Horiba LA930 Lazer Particle Size Analyzer. These samples were first sieved through a 63 micron sieve (note the apparent presence of material coarser than this fraction). An artifact of the processing algorithm is the cause of this. The fine fraction below 31 micron is also mostly an artifact of the instrument's processing algorithm, as demonstrated by conventional particle size analysis, using the classical pipette method.

San Andreas Fault at Tejon Pass Sample 13b...96 Hour Run



Below we present results to disprove previous attempts at utilizing a laser particle size analyzer.

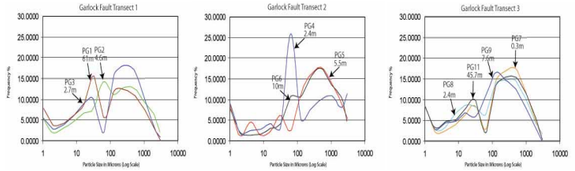
At 96 hours the circulation speed was increased from the default speed of 3L/min, to 3.5L/min and finally to 4L/min, with data collected at each interval.



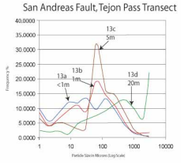
We took sample 13b (1.5m from the PSS), from the classic Tejon Pass locality and attempted to test earlier results that stated the importance of allowing a sample to circulate for several hours to completely disaggregate grains with throughgoing fractures and produce a true particle distribution. In preparation we shook our samples for 24 hours to defloculate any clay sized particles. The results, demonstrated above, show that when a sample is allowed to circulate at a low speed (<3 L/min), for several hours, silt sized particles tend to settle out. This produces the incorrect particle distribution. When the circulation speed was increased, we reaquired a result remarkably similar to the original result, at 0 hours.

Classical Pipette Method/Standard Sieve Analysis

Garlock Fault at Tejon Ranch

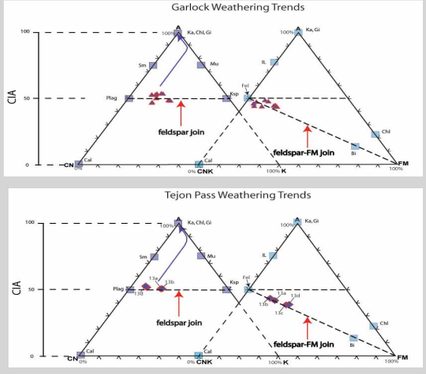


San Andreas Fault at Tejon Pass



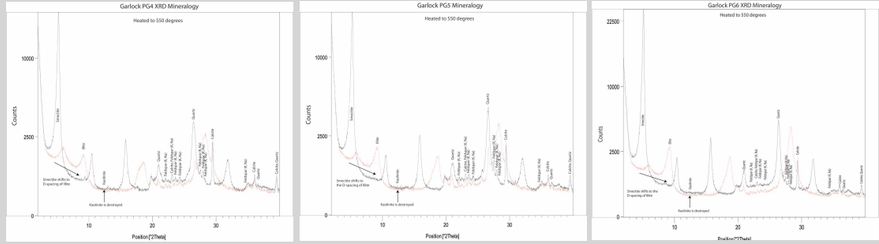
The results of the pipette analysis combined with standard sieve analysis. These samples were first shaken for 96 hours in a sodium hexa-metaphosphate solution. They were then sieved through a 63 micron sieve and each fraction was retained. The coarse fraction was dried and run through a standard sieve stack (at phi intervals) and the fine fraction was utilized in the classical pipette analysis. The results were combined and are depicted above. Each group is a transect of the afore mentioned localities. The samples are taken at various distances from the PSS in an attempt to demonstrate a possible trend outward from the fault core. Our analysis demonstrates no trend of increasing particle size outward from the fault core at the Tejon Ranch locale, but we do see a trend at Tejon Pass that does show a coarsening outward from the fault core.

Weathering Trends of Tejon Lookout Granite



The ternary diagrams above demonstrate the major and trace element analysis and the resulting CIA values, determined though XRF. Chemical Index of Alteration (CIA) is a measure of the amount of weathering a particular rock has undergone. Our values are well within the range of unweathered granite . The blue arrows are typical weathering trends for granitic rocks.

XRD Mineralogy Garlock Fault at Tejon Ranch Transect 2



We performed XRD analysis on the entire suite of samples for the Tejon Pass and Tejon Ranch locations. We utilized the <4micron fraction of the samples to determine the presence of clay mineralogy. The mineralogy depicted above demonstrates the existence clay minerals in the finest fractions and this will have a direct effect on the particle distribution of any pulverized granitic rocks. Many of the samples from both locations have approximatley 10% of the distribution in the <1micron fraction, and we have confirmed that this can be attributed, in part, to the presence of clay minerals and not solely pulverized material.

Conclusion

Particle size distribution of pulverized rock varies by locality, distance from the fault and diverse structural history that a particular rock unit has been exposed to. The San Andreas fault has over 300km of displacement and the Garlock has approximately 64km. Both have quite varied tectonic histories. The Tejon Lookout Granite has been subjected to a variety of structural environments in conjuction with both faults and it's present state, at the study areas is a direct result of this. These highly fractured and damaged outcrops have been sampled in a systematic fashion from the fault core outward. These samples have demonstrated that the grain size reduction produced along these faults are quite coarser than previously reported by Wilson at al. While the chemical anaysis demonstrates the lack of significant weathering, the XRD mineralogy confirms the presence of clay minerals in the finest fraction of the particle size distribution. Our calculations of energetics during dynamic pulverization confirm that much less than 1% of the surface energy is consumed by grain size reduction, based on the mean particle size for our samples (~63 micron).