PSCharacterizing Fracture Networks in a Normal Fault Splay Zone*

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Abstract

The Plaza Blanca fault is located NE of Abiquiu, New Mexico. The fault splays into two SE-dipping, synthetic normal faults. Several studies attribute increased damage zone width and decreased fracture density from the fault core to the magnitude of fault throw. At this fault splay, the damage zone becomes more complicated as two major faults interact. A fundamental issue in the field area is the interaction of groundwater with the Abiquiu formation. Hypothetically, ground water will utilize the fracture network associated with faulting as a conduit for fluid transportation. To fully understand such implications several studies are conducted. We employ the 2m diameter circular window method and measure fracture orientations, lengths, apertures and connective facets to determine fracture variation along and across the splay zone. There is a positive correlation among fracture frequency, intensity, and structural position. Fracture frequency (FF) is defined as the number of fractures per unit area (L0/L2 = L-2), and fracture intensity (FI) is the cumulative length of fractures per unit area (L1/L2 = L-1). Background fracture has low frequency (FF = 1-9 m-2) and intensity (FI = 1-3 m-1). In the damage zone surrounding the splay, both indices increase (FF = 12-124 m-2, FI = 5 - 9 m-1). Within the splay zone, FF and FI are even higher (FF = 10 - 53 m-2, FI = 6 - 12 m-1). The fault core of one splay displays very high values (FF = 128 m-2, FI = 10.8 m-1), while the highest frequency occurs exactly on the splay point (FF = 195 m-2). Proximity to the fault core shows higher fracture intensity, frequency, and thus higher connectivity. Results reveal a logarithmic scaling relationship with fracture length and aperture. Three connective nodes types within each circle are plotted on a ternary diagram: isolated tips (Inodes), abutting fractures (Y-nodes), and crossing fractures (X-nodes). Background fractures generally have little connections (I = 30-70%, Y =30-70%, X=0%); those from the outer part of the damage zone show an increased connectivity (I=25-40%, Y=55-75%, X=0-5%). Fractures are highly linked within the splay zone with elevated proportion of Y- and X-nodes (I = X = 8-16%); and the highest connectivity is found at the splay point (I = 8-9%, Y = 55-56%, X = 35-36%). Further characterization of the fracture networks are represented in gigapixel imagery. Porosity and cementation studies are forthcoming.

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Introduction:

- 1. Fracture frequency increases with proximity to the fault core. Frequency is also high at the "splay point."
- 2. The orientation of the fractures remains constant at varying sizes. There is some disorder with shorter length fractures.
- 3. Fracture frequency has a positive linear relationship with fracture connectivity.
- 4. Increased fracture density may provide potential pathways for fluid transportation (i.e. surface and ground water). Cementation and grain reduction may inhibit fluid flow in fracture networks.

Implications:

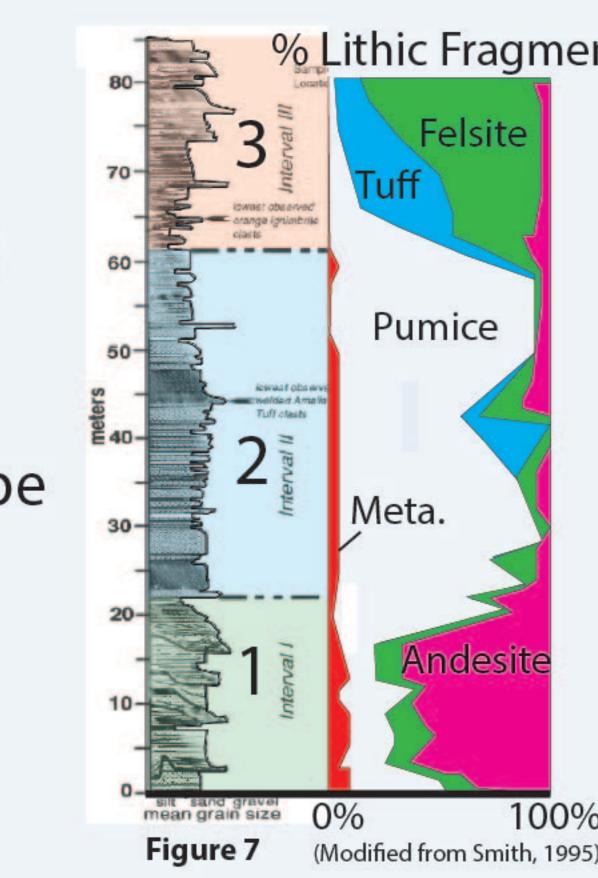
Analyzing the fracture network properties in this splay zone should provide useful information for understanding the underground fracture networks.

Fractures can provide pathways and barriers for fluid flow. Understanding these interactions have benefits for the hydrology and petroleum industries.

Stratigraphy / Throw:

Measured sections of the Abiquiu Formation are used to estimate throw. (See the measured sections on the right)

Three different intervals are defined and may be identified by looking at the lithic fragments and sedimentary facies.



Section 1 is located in the HW and is from interval 2 as is Section 5.

Section 2 is located in the FW and is from interval 3.

The total throw is greater than 50 meters.

Throw may be even up to 250 meters based on the total thickness.

This normal fault splay is large enough to be detected seismically.

Regional Geology:

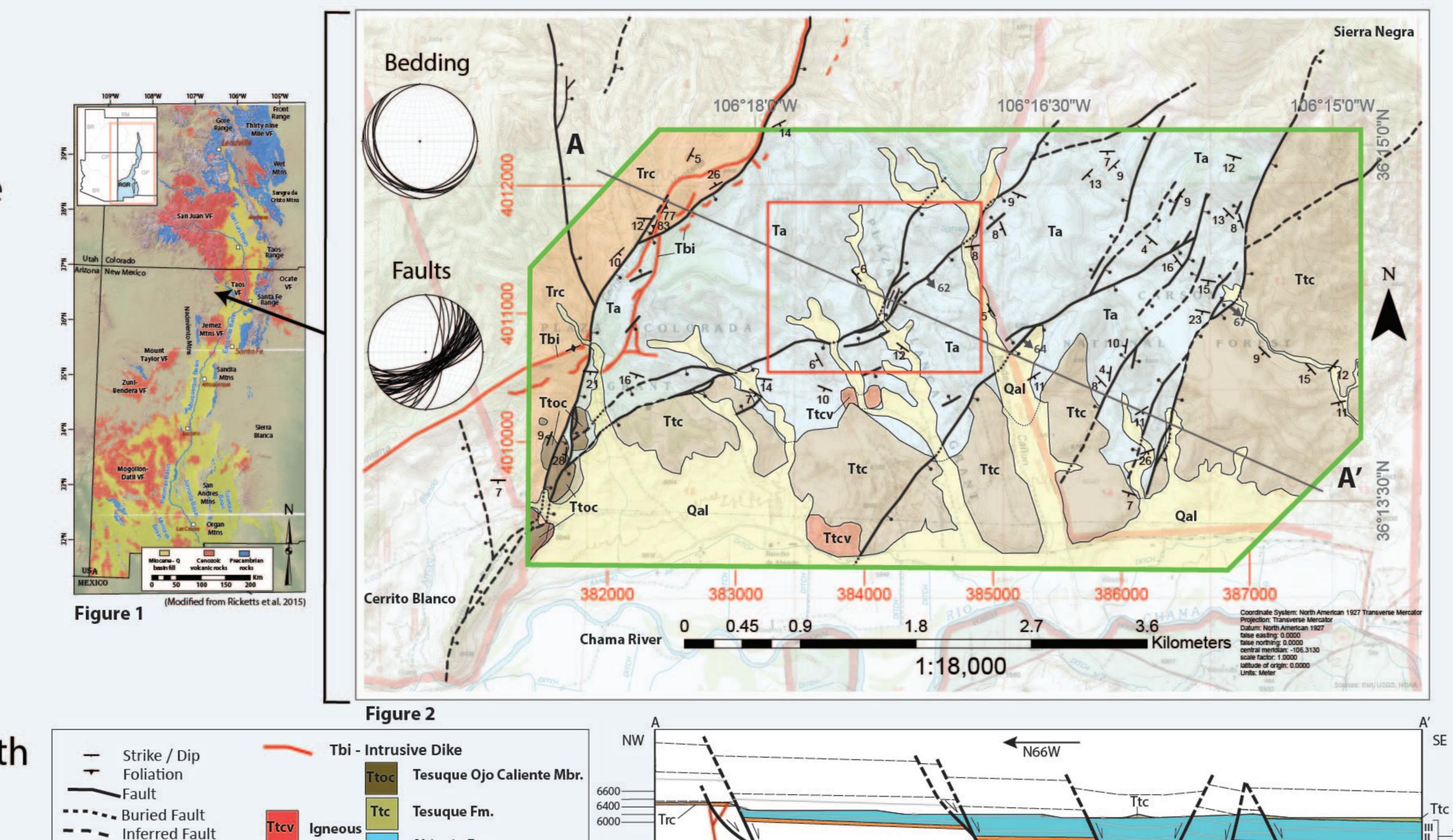
The Plaza Blanca Land Grant is in Northern New Mexico near Abiquiu.

The prevailing tectonic environment is a large scale extensional regime known as the Rio Grande Rift (RGR).

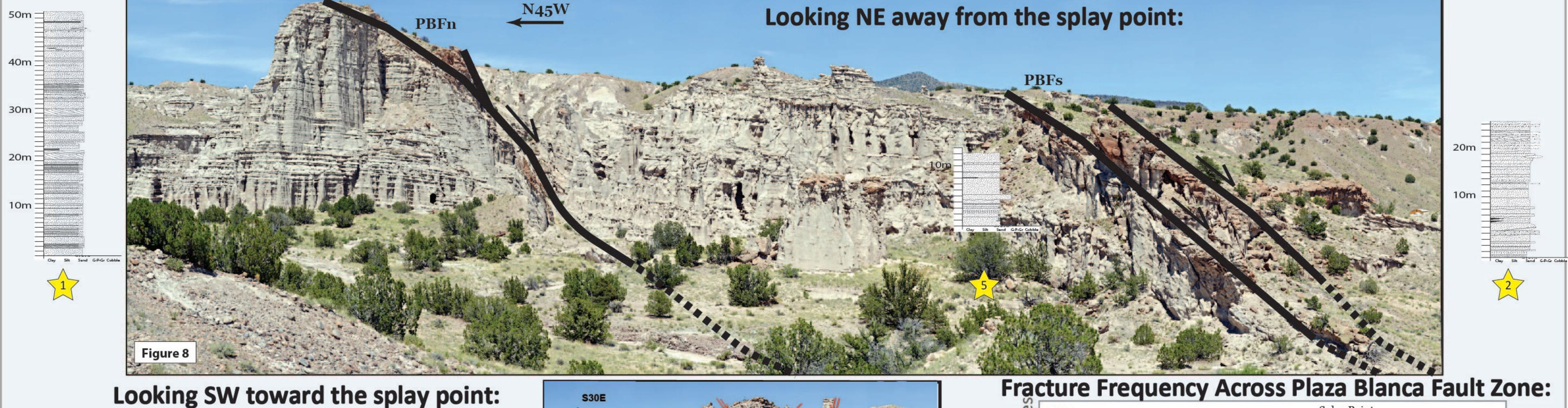
A normal fault splays in the Miocene aged Abiquiu Formation (Ta). It is characterized by a well preserved fault core and associated fractured damage

Ta is a volcarenite sourced from the San Juan and Latir volcanic fields.

This fault is dubbed the Plaza Blanca Fault (PBF) with a north and south component. (PBFn & PBFs)



High Resolution Imagery:



- Gigapixel images are used:
- -To correlate stratigraphy

circular windows can be applied to outcrop.

-Characterize connectivity

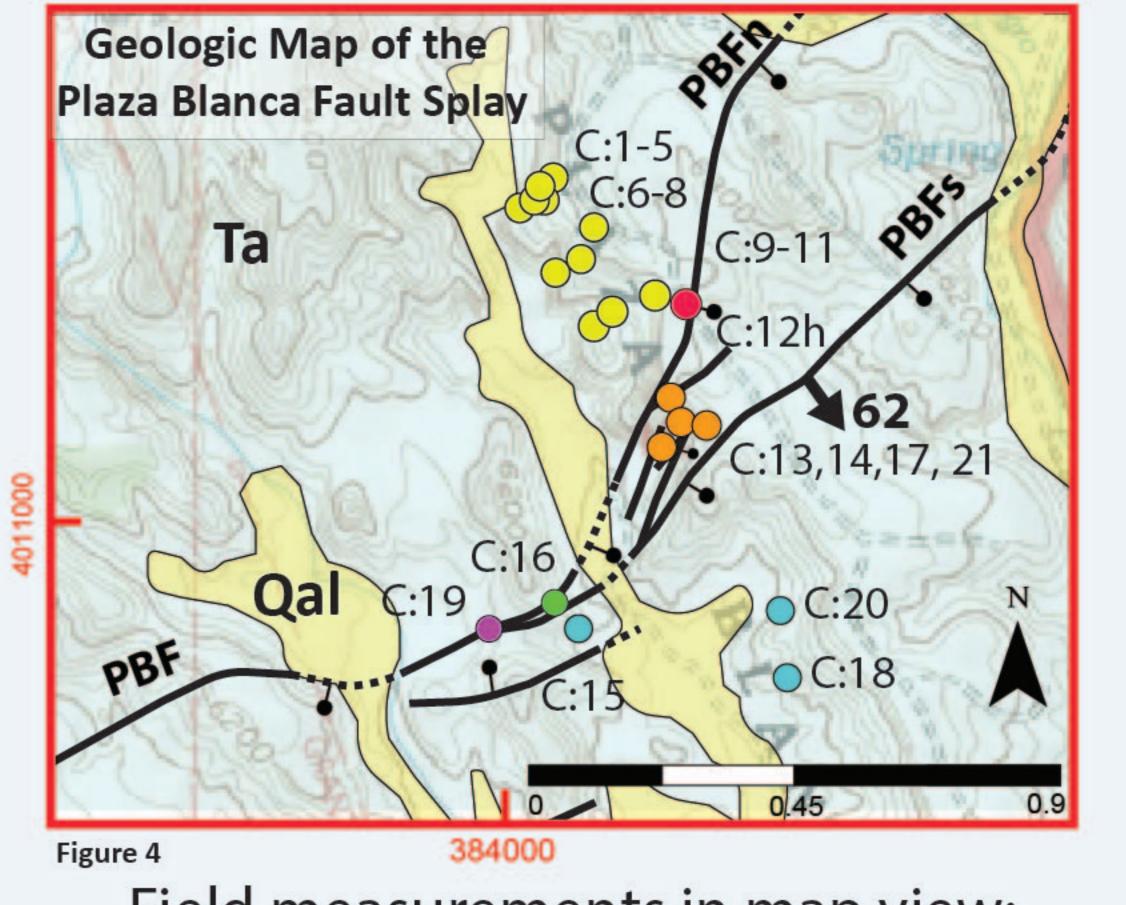
-Measure fracture frequency.

The same procedures used in the map view

Figure 10 Location of Circular Windows in the Splay Zone -Fracture frequency increases at the fault core and "splay point." -Fractures per window never exceeds 100 in the HW and FW.

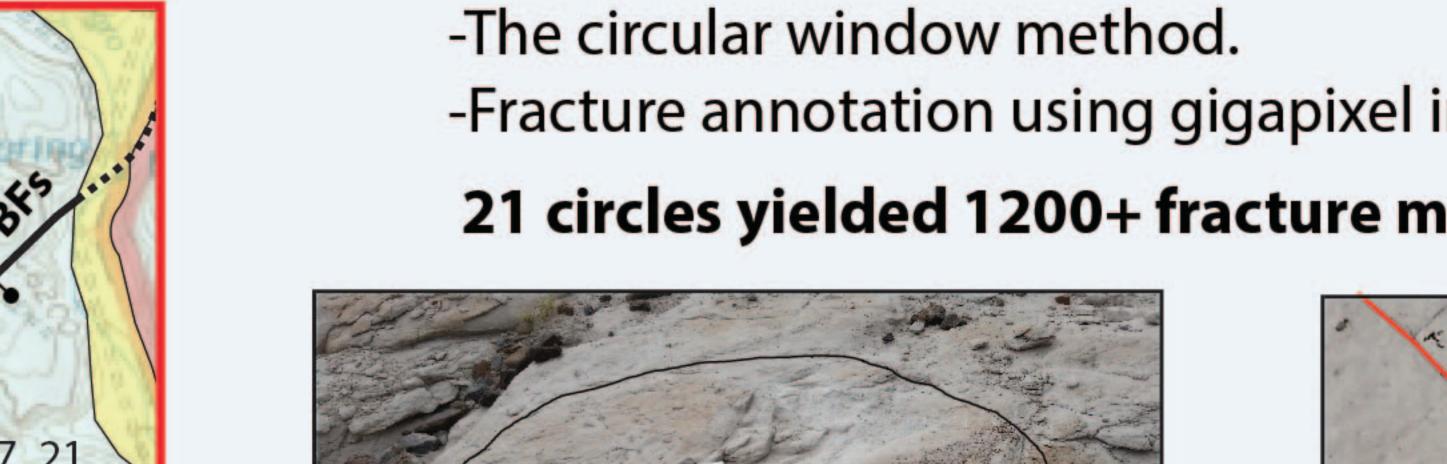
Geologic Map of the Plaza Blanca Region Field Investigation:

Foot Wall



Field measurements in map view:

- -Strike and Dip
- -Length
- -Aperture





-2m diameter

Techniques to characterize fracture relationships:

-Fracture annotation using gigapixel imagery.

21 circles yielded 1200+ fracture measurements.



Circular Window Method: -Avoid directional bias

- -0.9-1.2m thick beds

- Connectivity: I - ends of a fracture
- X intersecting

Y - abutting

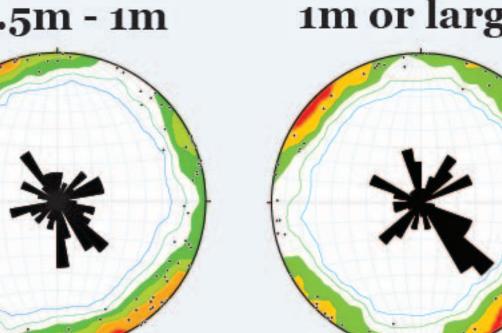
Results: Poles to fracture planes from the circular window data:

-Contoured to depict orientations of fractures of all scales and locations. -A primary orientation of ~N50E is evident in all scales.

Contoured poles to fractures:

Fracture length:

-Smaller fractures are more chaotic.



-Longer the fractures are regularly oriented.

Number of Fractures vs. Connectivity:

Characterizing fracture connectivity: $C_B = 2 \cdot (3Y + 4X) / (I + 3Y + 4X)$

-Using topology to characterize a fracture network. -Various fracture geometries may be represented on this ternary diagram.

-High connectivity at the splay point (purple) and fault core (red)

Total Number of Fractures

-A linear correlation between # of fractures and connectivity. Figure 13 -The greater amount of fractures, the higher the permeability potential.

References:

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