3D Analysis of a multiple dike intrusion and later deformation, Independence Dike Swarm, California.

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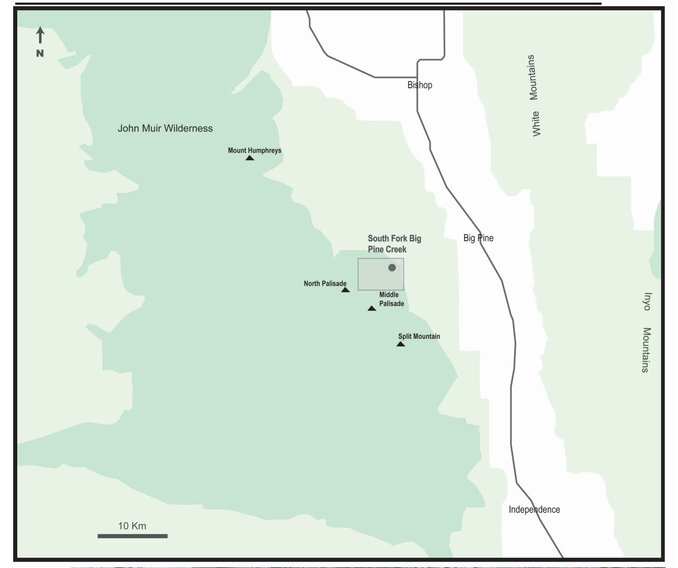
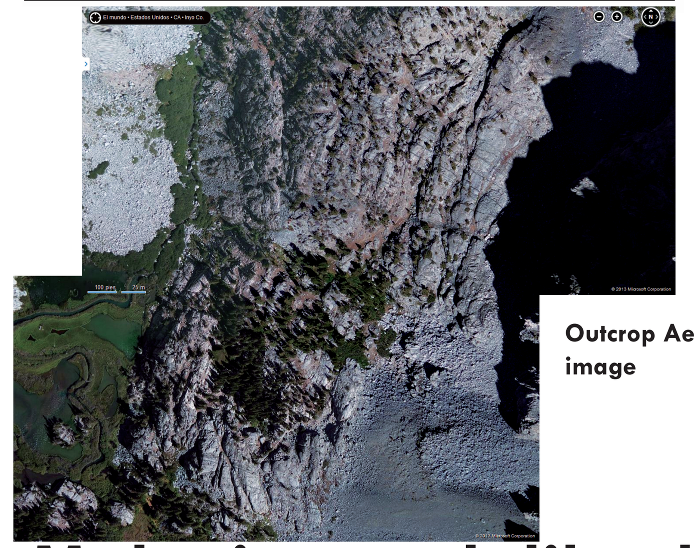
Geological Setting





Outcrop Aerial image

The study area is located in Sierra Nevada, Califronia.

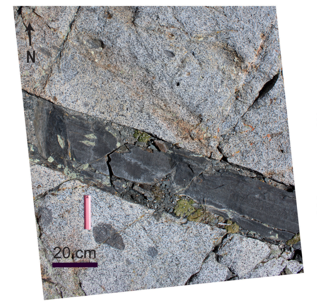
The data have been collected from an exceptional and accessible outcrop along the South Fork Big Pine Creek in 3D sections of vertical dikes, due to the glacial polish which gives drumlin morphologies.

The Independence Dike Swarm is exposed through more than 600km from East-Central to Southern California, with a NW-SE mean strike. The age is late Jurassic (~148 Ma.)

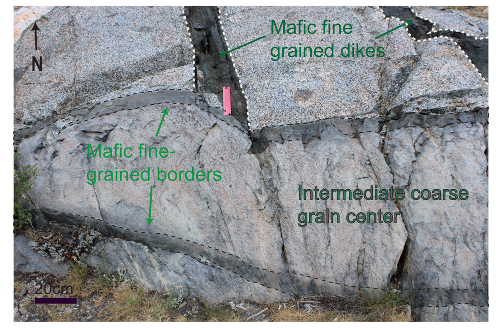
Typology of dikes

Crosscutting relations reveal the chronological order of the different intrusion sets:
· Intermediate N-S coarse-grained dikes (pre IDS)
· Composite dikes with intermediate fine-grained centers and mafic fine-grained borders (~E-W trend, IDS)
· Mafic fine-grained dikes (~E-W trend, IDS)
· Composite of xenoliths of mafic material and wall rock (~NNE-SSW, late IDS)

The mean dike direction is ~N95°, secondary set at ~N175°

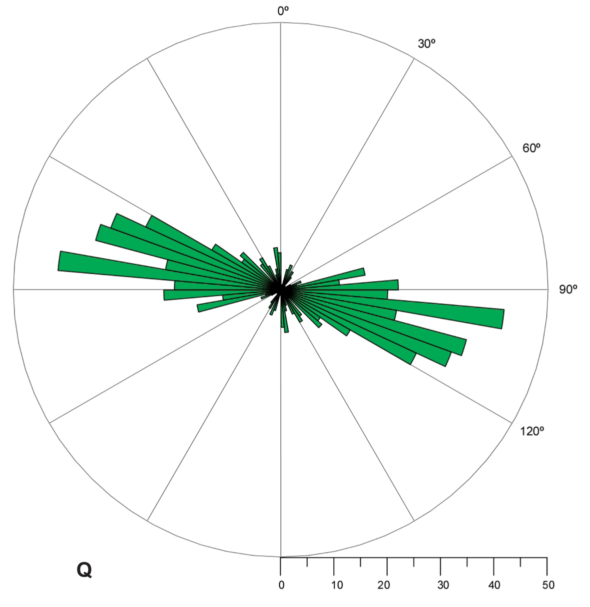


Mafic fine-grained dike



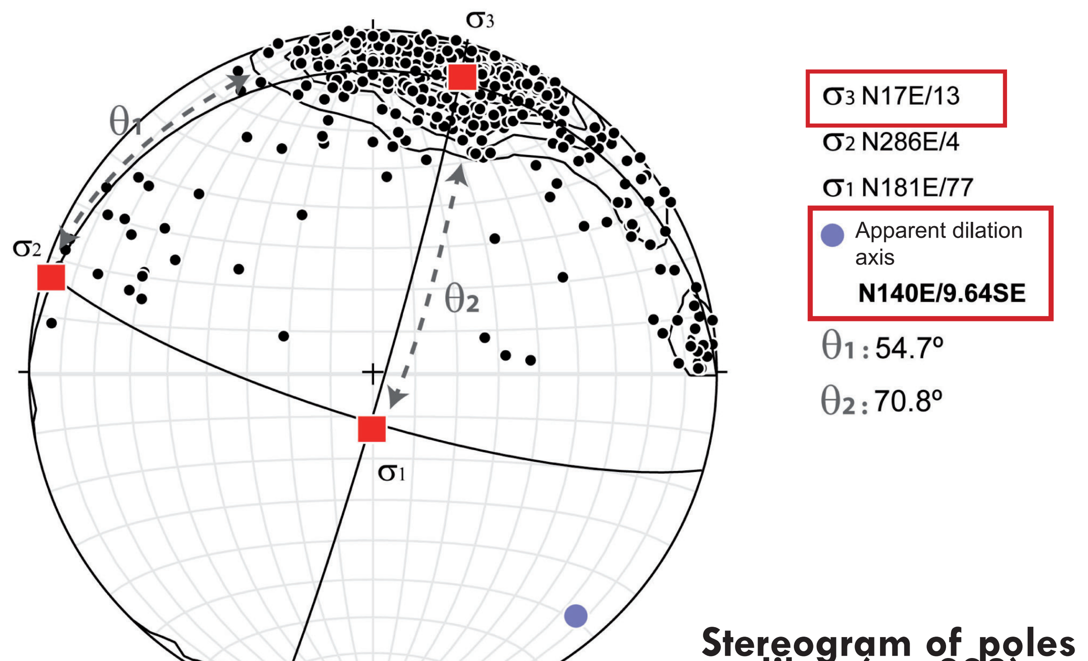
Composite dike

Composite of xenoliths of mafic material and wall rocks

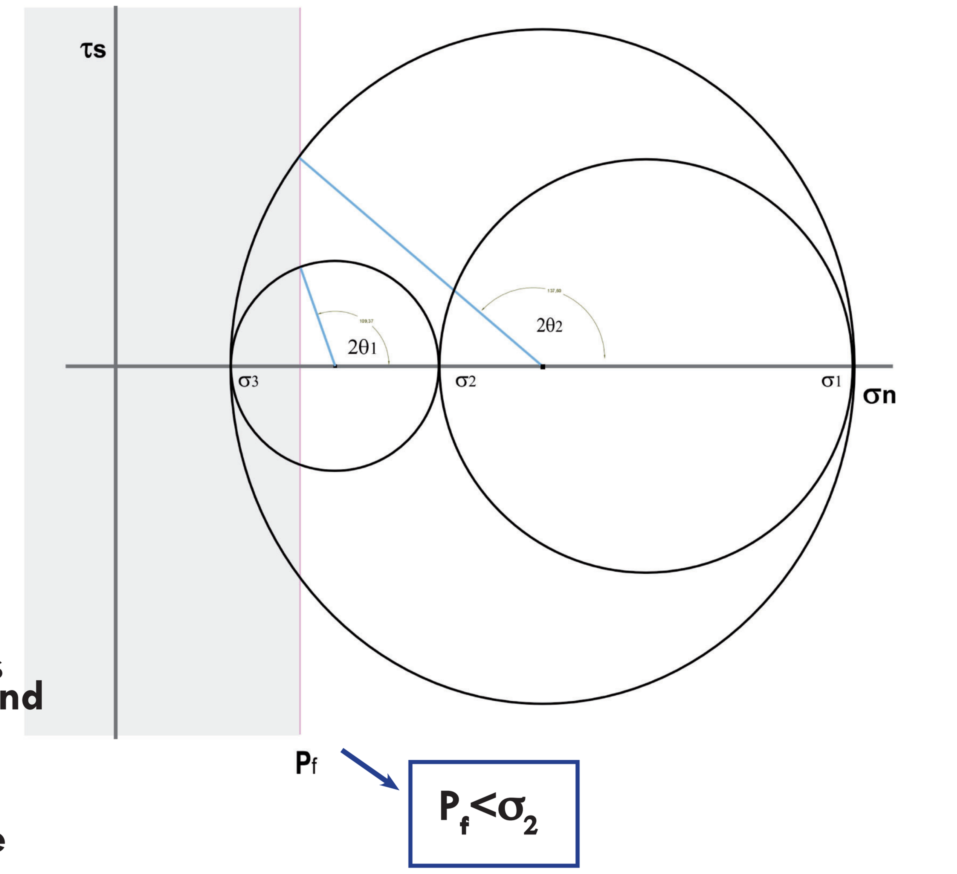


Dike trends

3D Stress analysis



Stereogram of poles to dikes (n= 338) and contours



Mohr circle construction for the IDS at South Fork Big Pine Creek (Jolly and Sanderson, 1995 method)

When $P_f < \sigma_2$ the equations used to get the **driving pressure ratio** (R`) and the **stress ratio** (Φ) are:

$$\Phi = \frac{\sigma_2 - \sigma_3}{\sigma_1 - \sigma_3} = \frac{\tau_{max\,1}}{\tau_{max\,2}} = \frac{1+\cos 2\theta_2}{1+\cos 2\theta_1} \qquad \Phi = 0.324$$

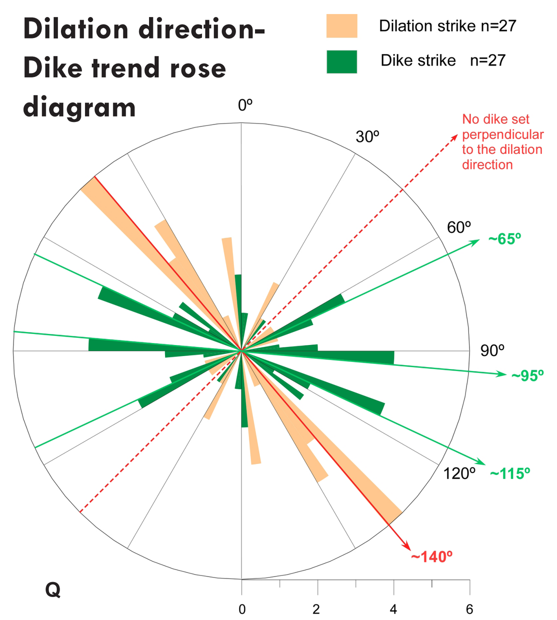
$$R' = \frac{P_f - \sigma_3}{\sigma_1 - \sigma_3} = \frac{a}{2\tau_{max\,2}} = \frac{(1+\cos 2\theta_2)}{2} \qquad R' = 0.1085$$

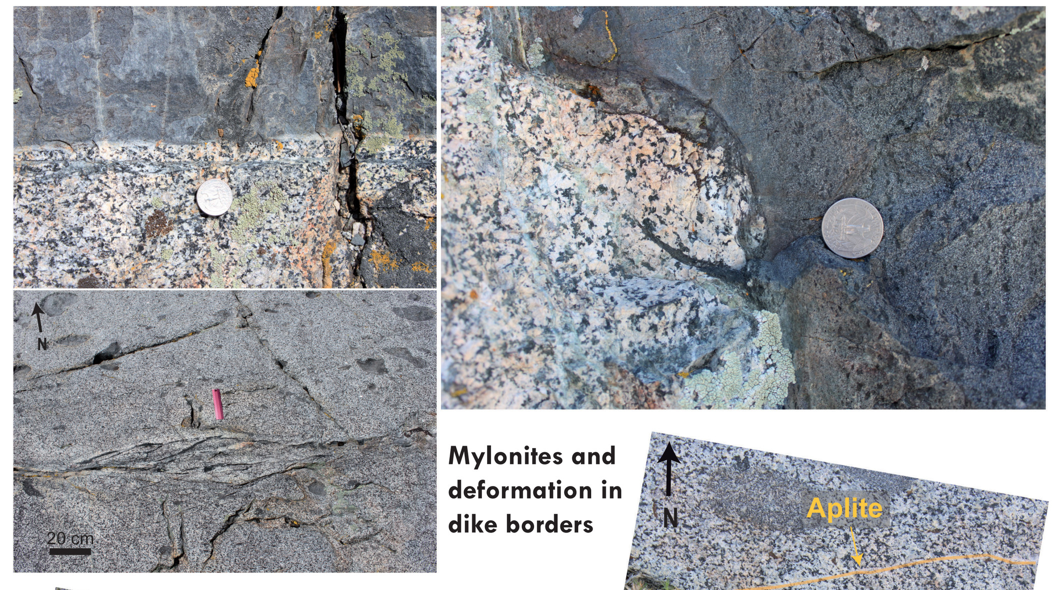
· σ_2 and σ_3 are smaller than σ_1, this gives a very important role to the tectonic mechanism and the pre-existing fracture pattern in the host rock during the intrusion event.
· The apparent dilation axis measured in the field (~N140E/9) does not match with the σ_3 axis (N17E/13) obtained by this method, this imply at least a later shearing episode that produced an approximate 47° anticlockwise rotation of the original dilation axis .

Mylonites and dike deformation

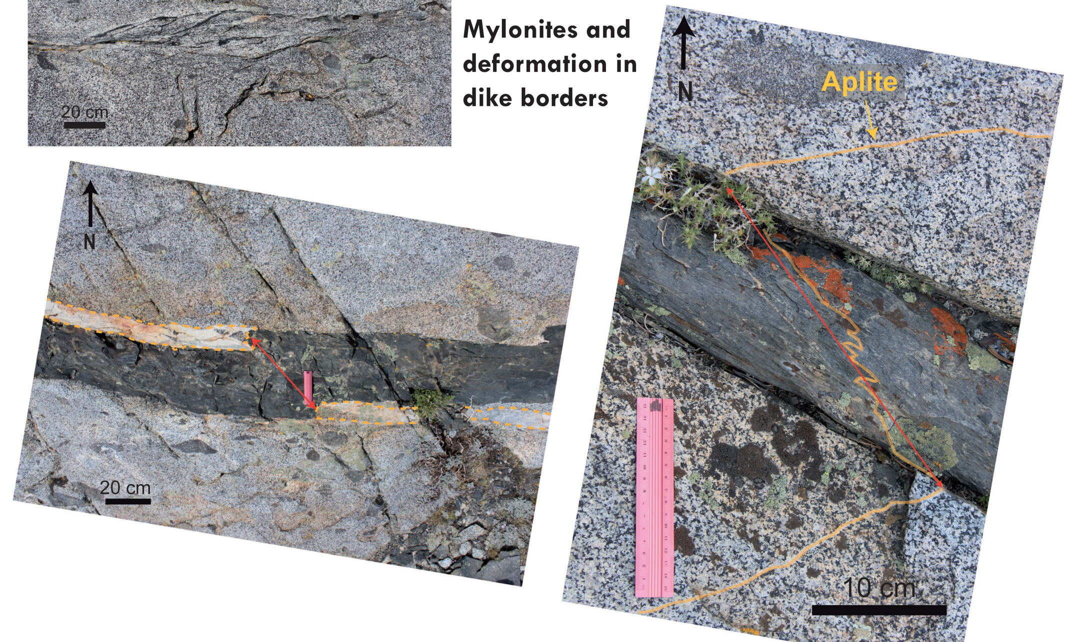
Measuring the offset direction of Pre-dike aplites and dike jogs we obtain the net dilation strike, which is **~140°**
* Measured offset vectors do not agree with opening vectors predicted by stress analysis.
* There is no dike set perpendicular to the opening direction.
* Markers in the host rock were displaced from their original positions by dike-parallel shearing, producing:
⟶ Tectonic fabric in dikes
⟶ Mylonite zones

Dilation direction-Dike trend rose diagram

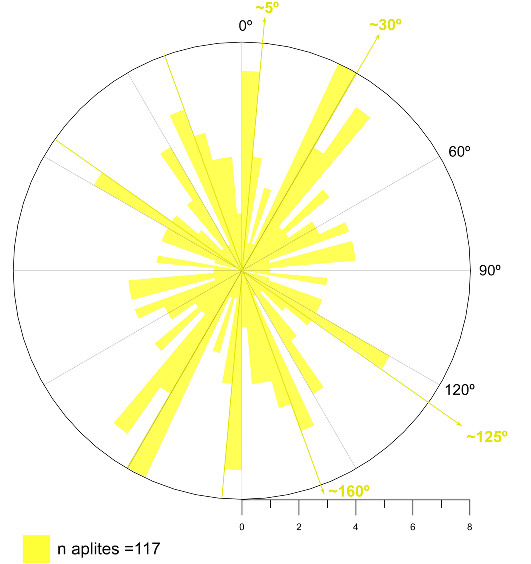




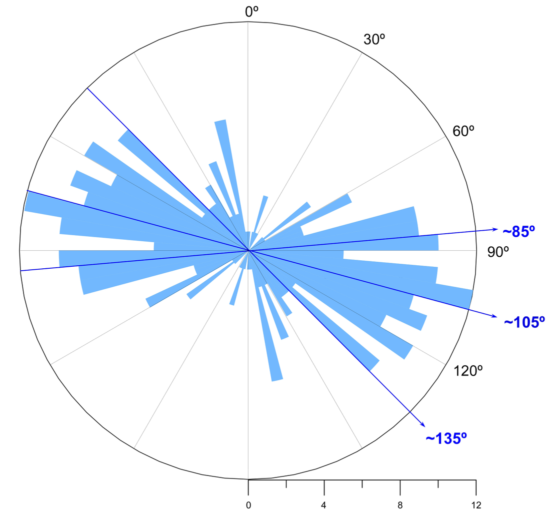
Mylonites and deformation in dike borders



Apparent opening direction



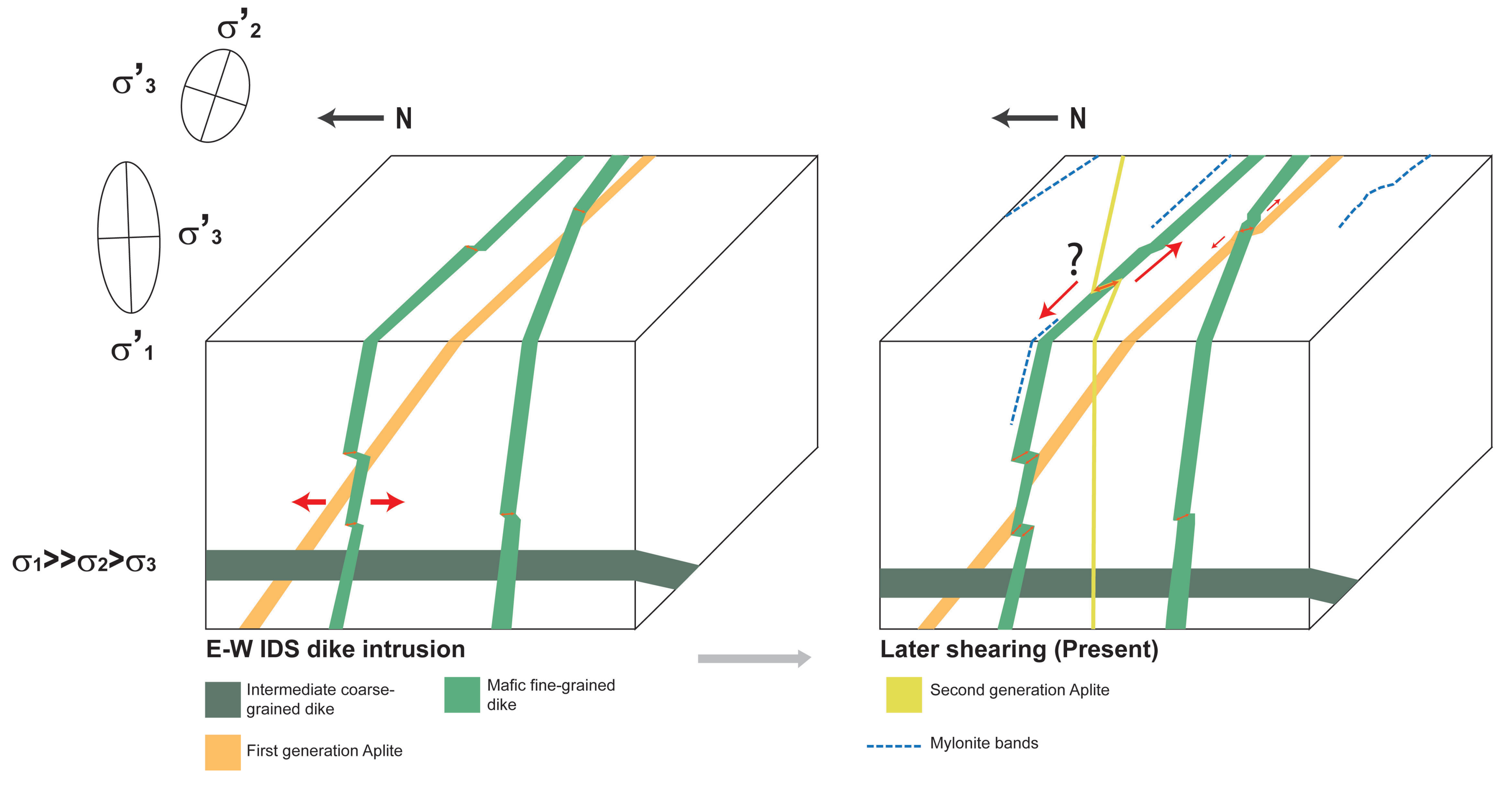
Aplite trend rose diagram



Mylonite bands trend rose diagram

Aplite rose diagram show a great scatter of pre-dike intrusion sets and other sets related to a post IDS intrusion late event.
Mylonite mean direction sets have a similar range to the mean IDS dike orientation, which can be related to a pre to sin-shearing event.

Model of dike emplacement



3D model for emplacement

· First diagram: This situation represents the stress state in the moment of the IDS intrusion, under an extensional regime.

· Second diagram: The proposed model for a later mylonitic shearing event with a sinistral component. This could explain the rotation of the apparent dilation axis seen in the Jolly and Sanderson analysis above, and the presence of mylonitic bands.

Conclusions

· $P_f < \sigma_2$, thus dike intrusion was not associated with magmatic overpressure conditions.

· σ_3 is sub-horizontal with a NNE orientation, σ_1 is sub-vertical (N181E/77) and σ_2 is sub-horizontal (N286E/4)

· Tectonic stresses changed from an extensional regime during dike emplacement to a later sinistral shear and mylonitization, we have two evidences of this fact:

1) The apparent opening direction obtained from field data does not correspond to the σ_3 axis of the Jolly and Sanderson analysis.

2) Localization of the deformation in mylonite bands in the host rock and near dike margins, as well as deformation and mineral lineation at fine-grained dike borders and deformed aplite veins.

· This could lead to question the validity of the stress analysis, since we see evidences of deformation in the dikes after intrusion. We infer an overprinting shearing that modifies the pattern of the apparent opening vectors where the strain is limited to dike-parallel shear bands. However, dike orientations has not been notably modified, as a result, we consider the stress analysis to be valid.

References

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