



# Neoformed faulting and fracturing with conductive characteristics in the Acoculco geothermal system, Puebla, Mexico.

Víctor Hugo Garduño Monroy

Adrián Jiménez Haro

María Félix Gaytan Ramírez

Fidel Gómez Álvarez

Montserrat Magaña Ortega

Oscar García Hernández

Sergio Nájera Blas

Hatziri Ojeda

Luis Olmos Navarrete

Alejandro Ávila Olvera

Isabel Israde Alcántara

Domenico Liotta

Andrea Brogi

Walter Wheller

Eivind Bastesen

A.Torabi

Emanuel Olvera García

Alejandro Guevara Alday

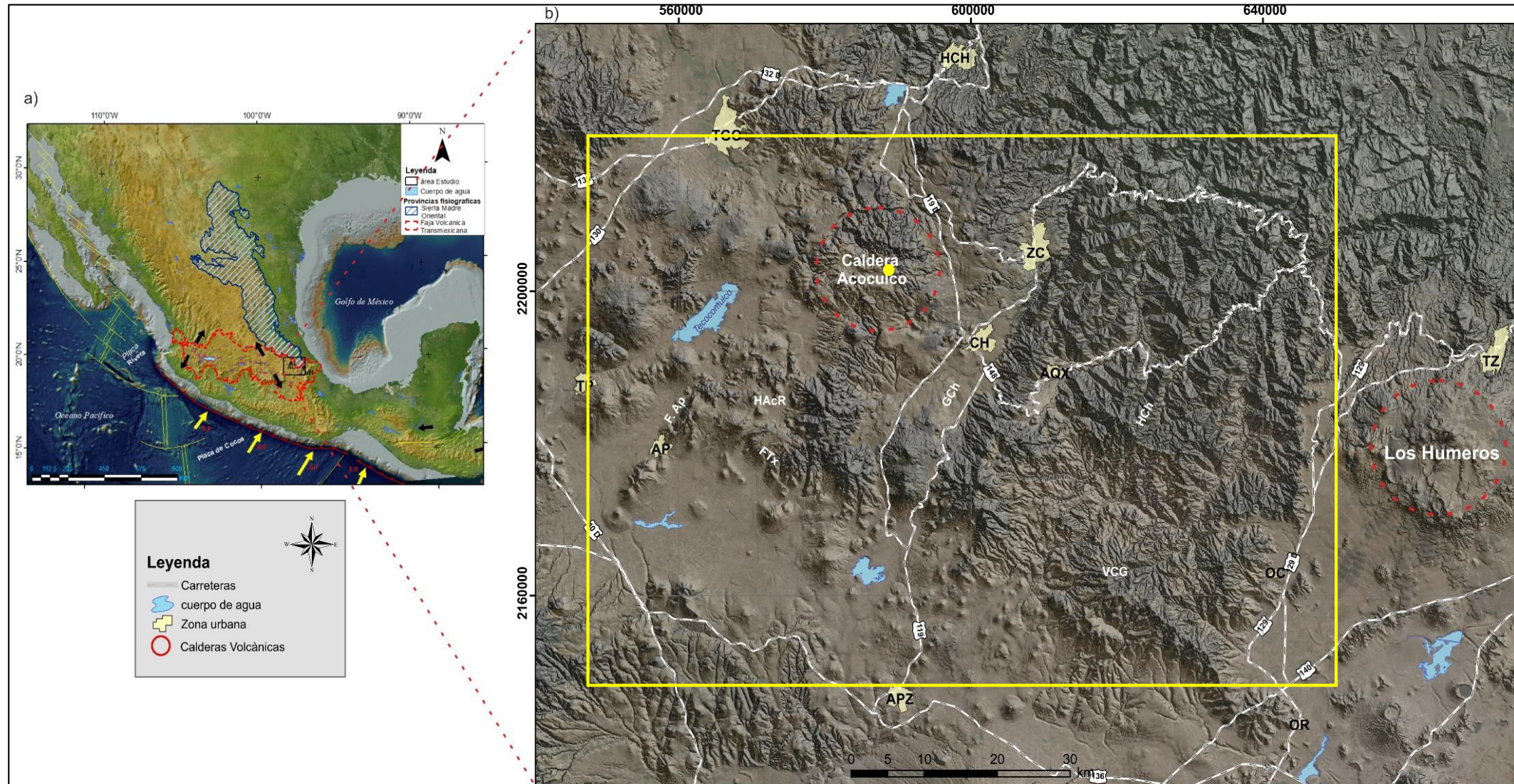
Martina Zucchi

Caterina BiancoArturo

Muñiz Jáuregui



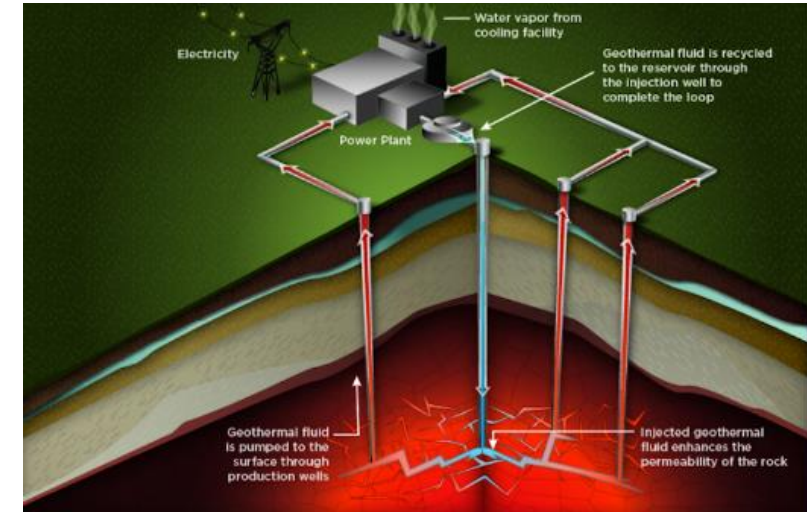
# Location





In the 1980's, the Comision Federal de Electricidad (CFE) began carrying out several studies including drilling two exploratory wells EAC-1 and EAC-2, which resulted in the documentation of temperatures up to 300 ° C but with zero permeability.

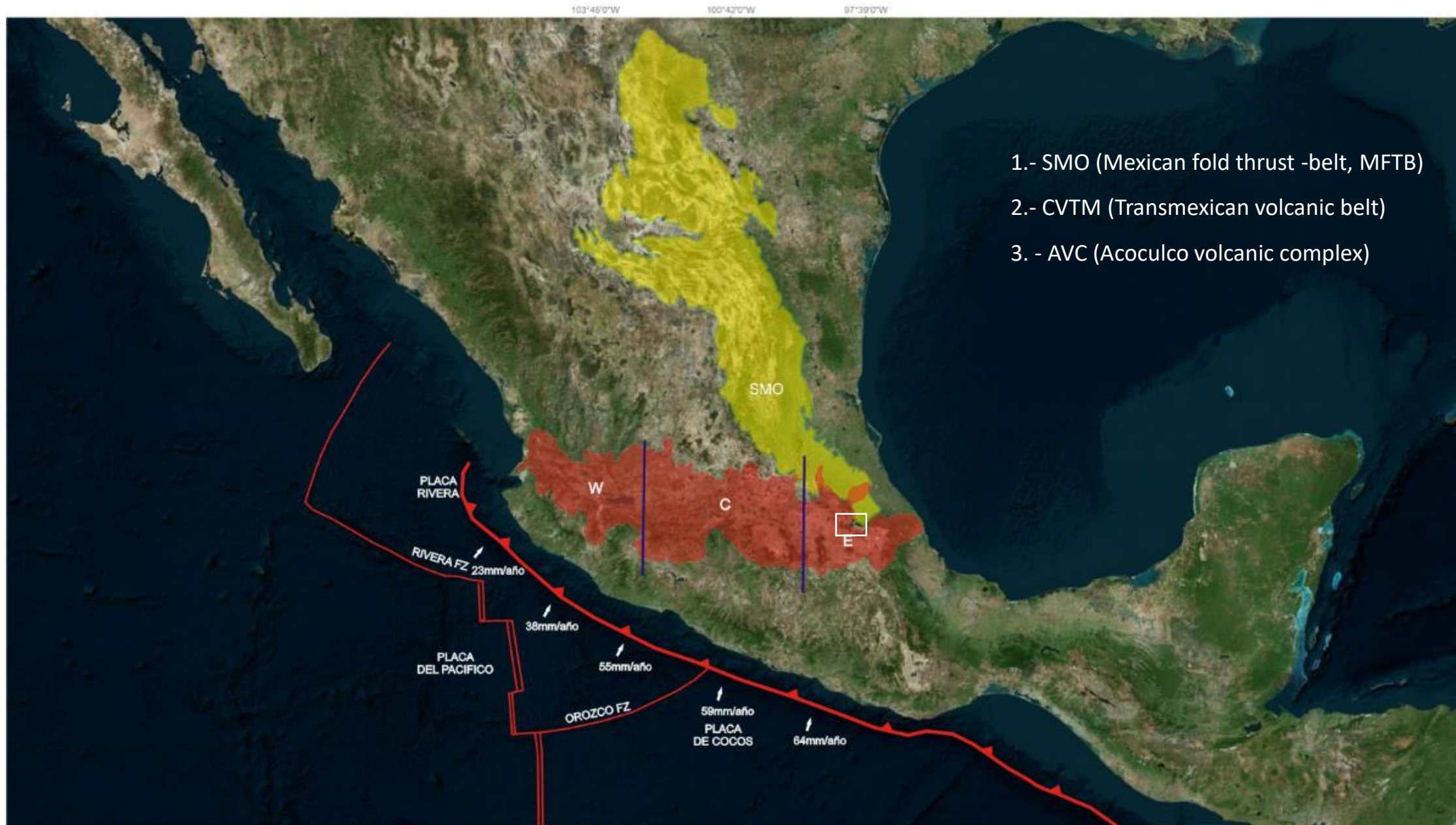
The high temperature and low permeability in Acoculco suggested the development of an EGS.



## Objetive

The objective of this job its complement the work done by the WP. 4.2. focusing on understanding the genesis and geometry of neofracturing and its relationship with the sedimentary units that interact with the Acoculco geothermal system.

To understand the distribution, genesis and the evolution of fracturing and faulting is necessary to considerate...





The MFTB constitute the basement  
of the region and is represented by

Jurassic - Cretaceous carbonate  
sequence





All these units have a distribution related to tectonic processes



Andesite Aquixtla group  
8-11 Ma



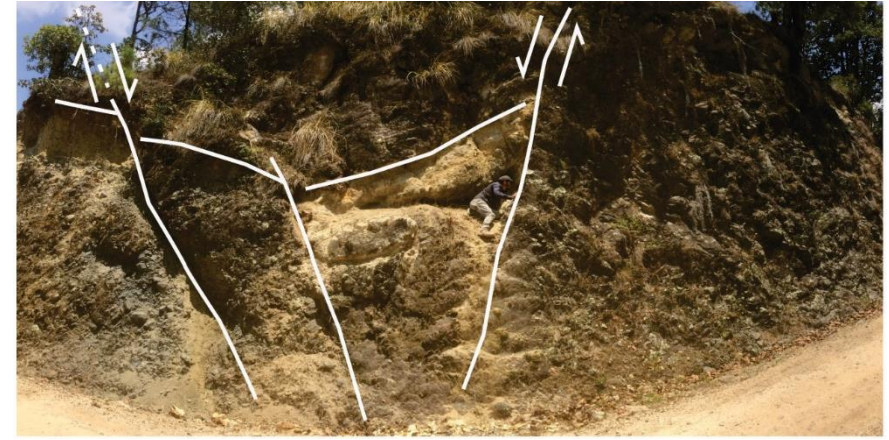
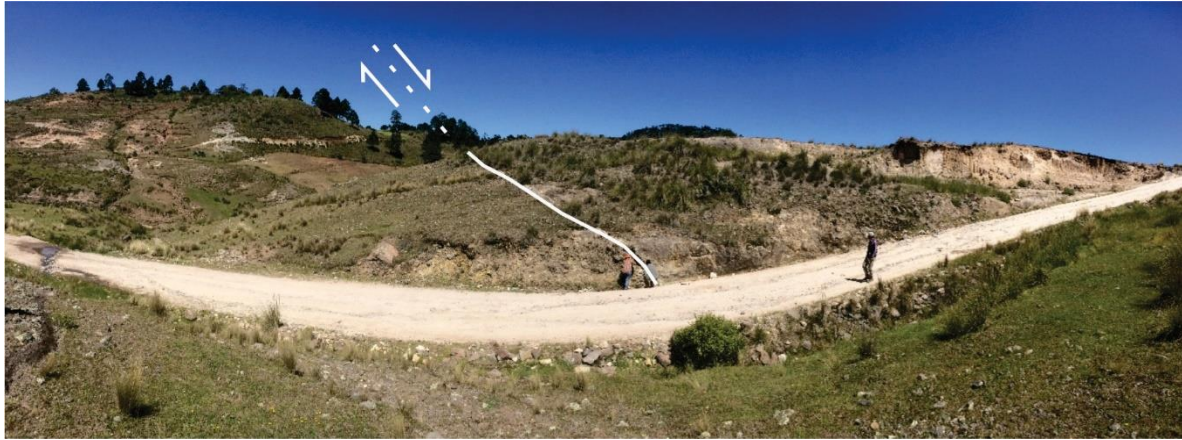
Matamoros Ignimbrite



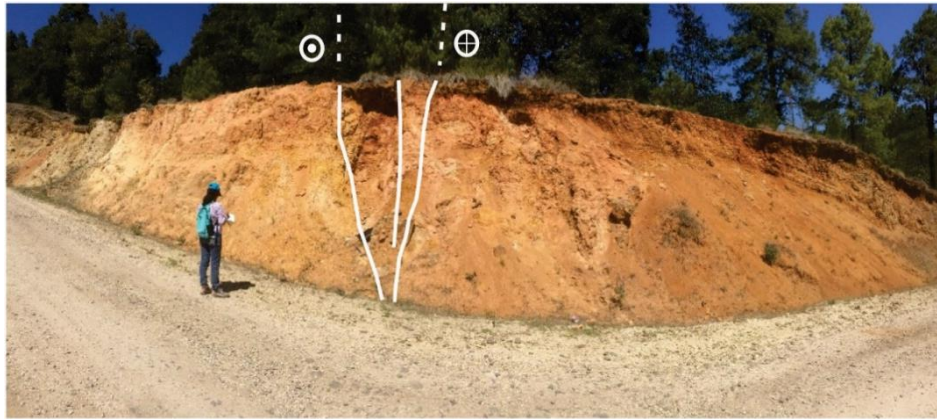
The TMVB is represented by  
a Volcanic sequence  
Mioceno - Pleistoceno



There are structures linked to the evolution of caldera and structures linked to the tectonic context.



AVC  
Volcanic units from  
Pliocene-Pleistocene



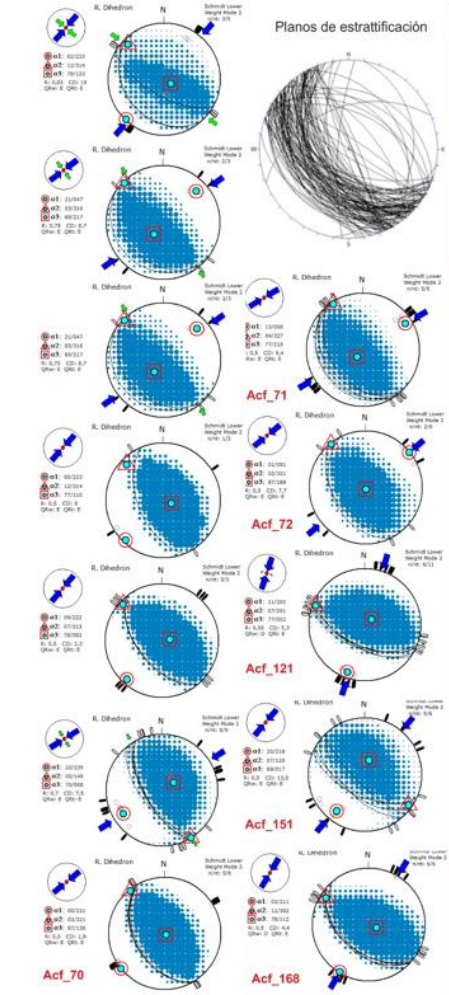
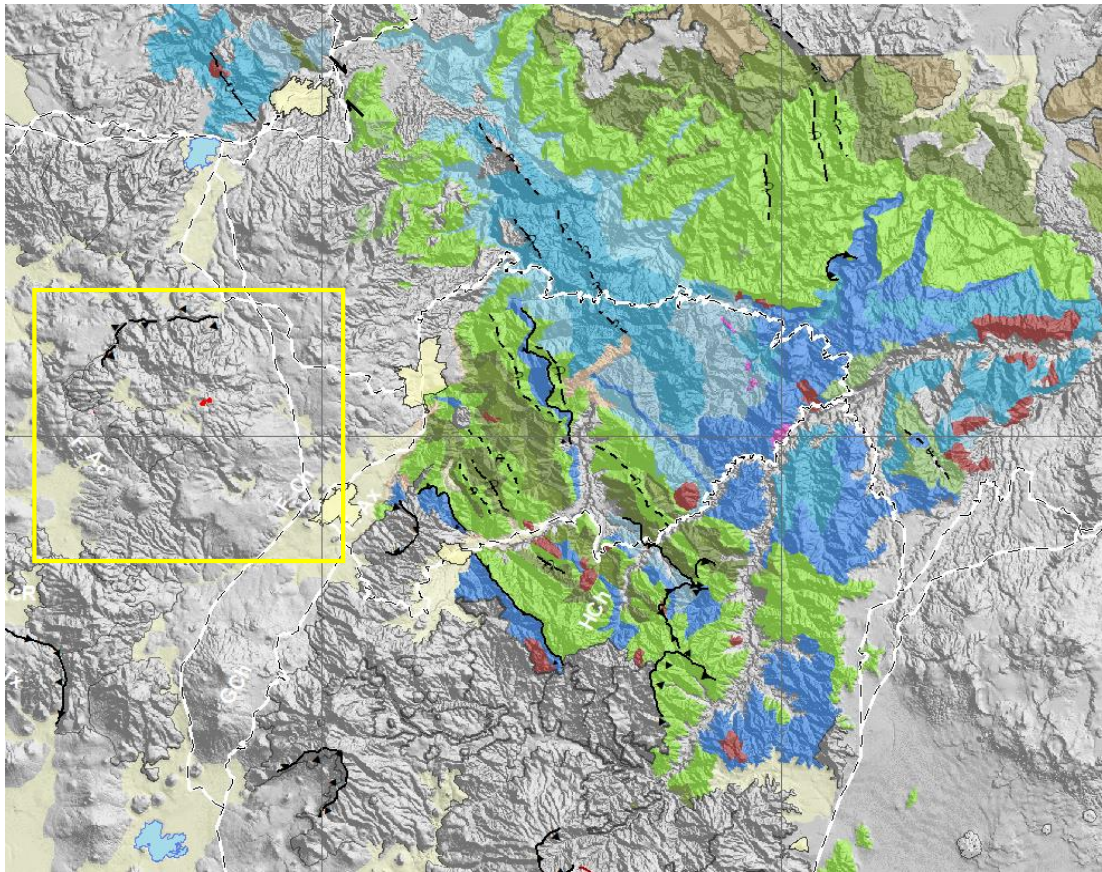
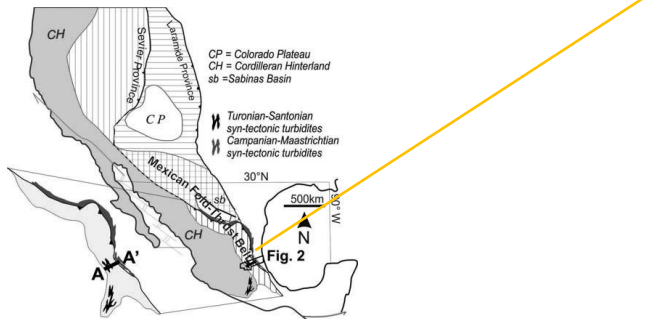


The faults and fractures in the region owe their genesis to 3 main deformation stages.

The result are folds of different styles and geometries with preferential direction axes NW-SW.

Stress tensor solution

**Stage 1**  
Laramide orogeny  
From late Cretaceous - Paleogene  
Shortening NE-SW



Different folding style with vergence towards to NE.



Open



Chevron



Close



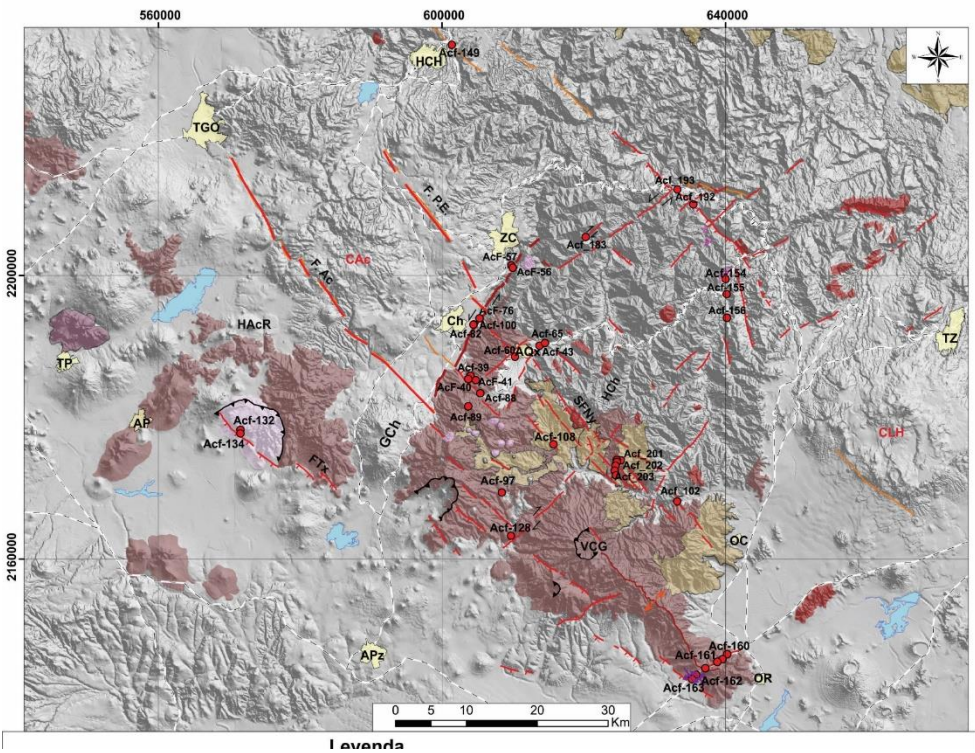
Reverse fault



# Stage 2 Miocene NE-SW Extension

This deformation stage was deduced taking into account several factors such as:

Distribution of volcanic units of 8-11



Eruptive fractures



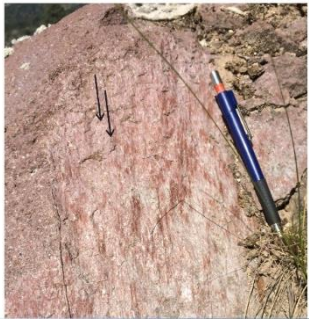
Large NW-SE faults



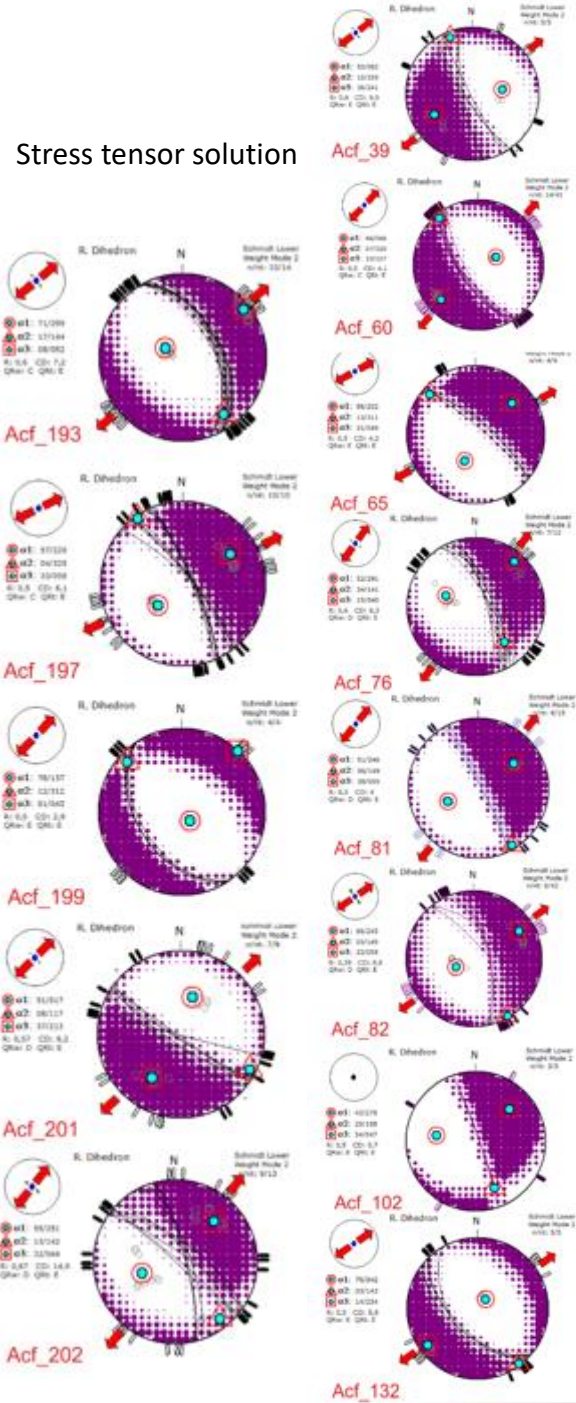
NW-SE Pyroclastic dikes



kinematics



Stress tensor solution

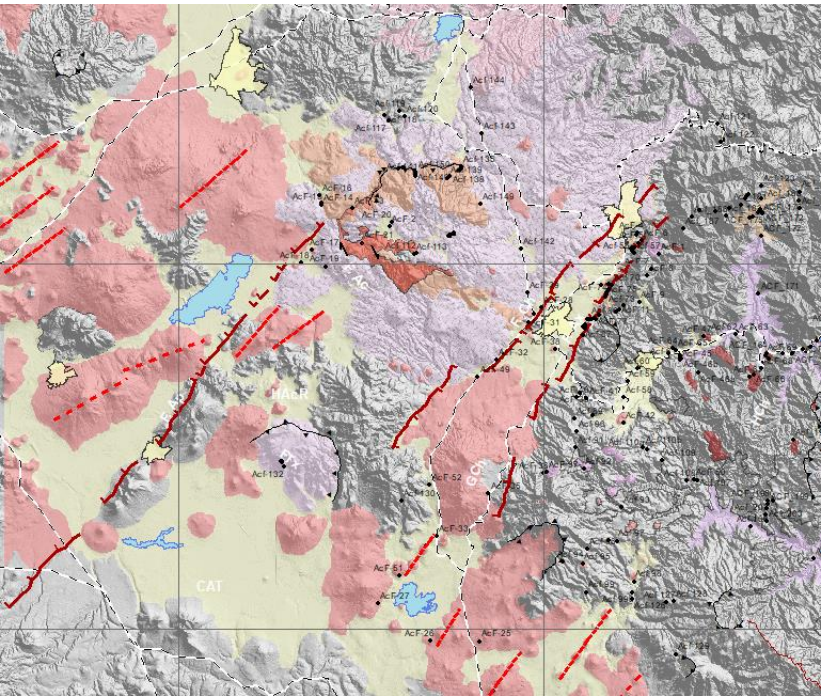




# Stage 3 Plio- Pleistocene NW-SE Extension

This deformation stage was deduced taking into account several factors such as:

Distribution of volcanism of ATVF Plio-Plei



Large NE-SW faults

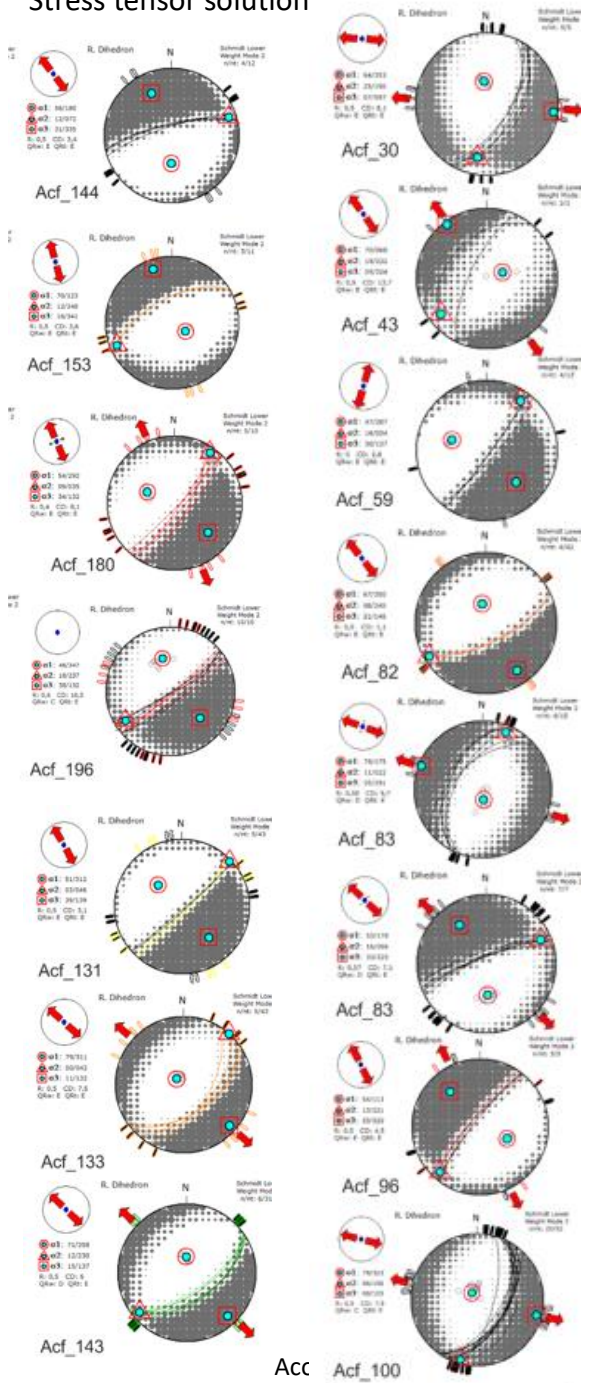


Chignahuapan Fault



Axaxalpa Fault

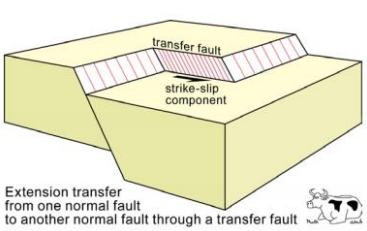
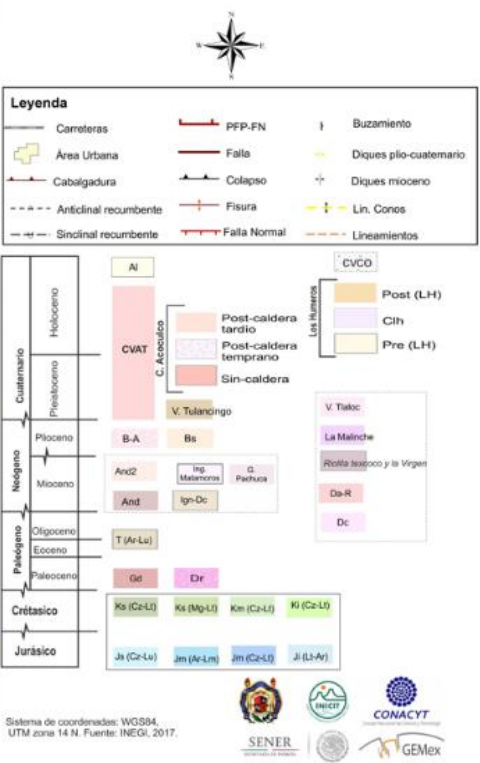
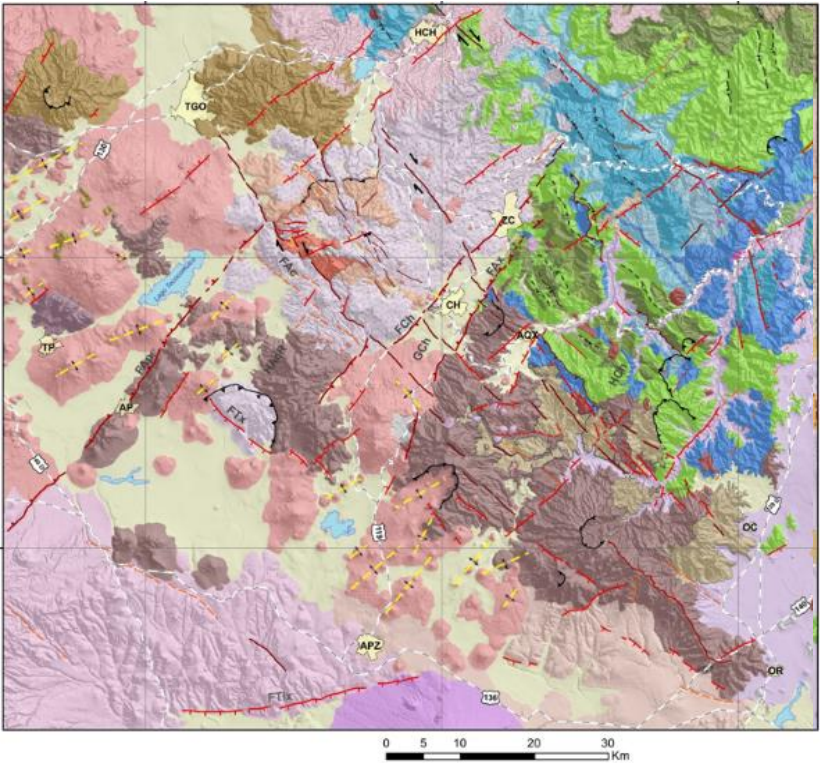
## Stress tensor solution



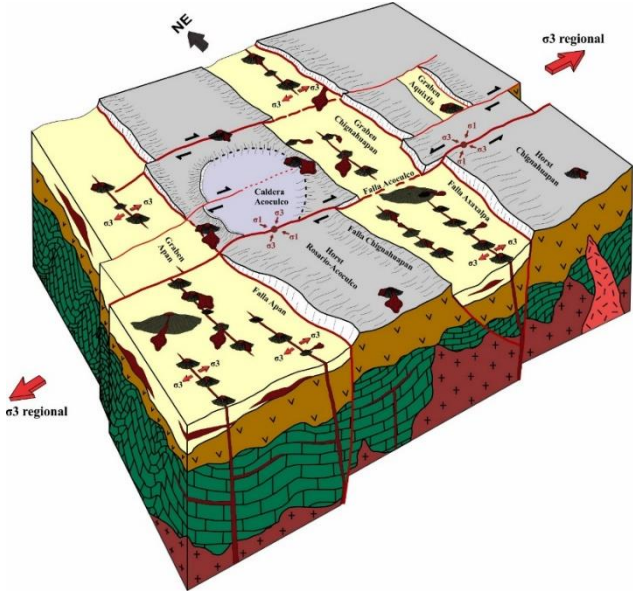


This is the result of the interaction of those structures.

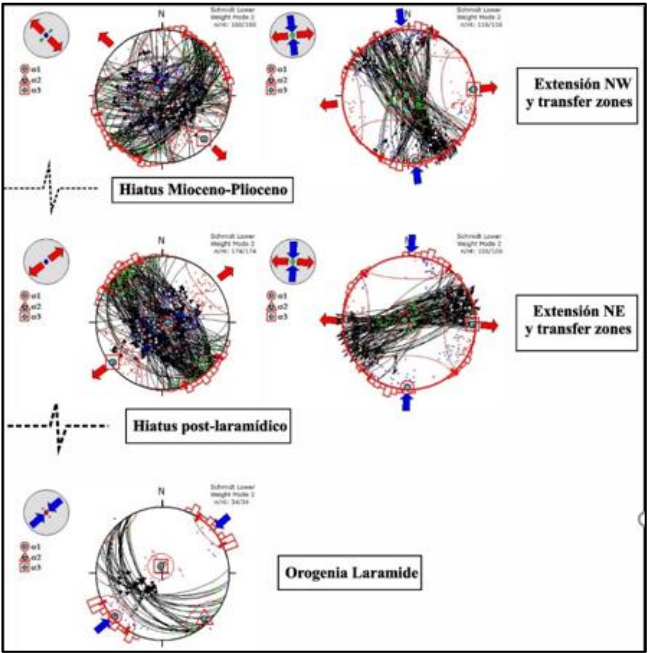
Two systems of faults that interact



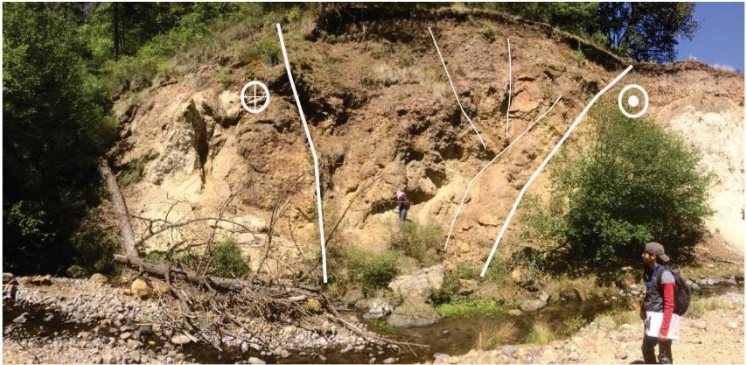
Schematic model of this interaction



Stress tensor solution



The NW-SE structures were reactivated but with a lateral movement



NW-SE right lateral fault



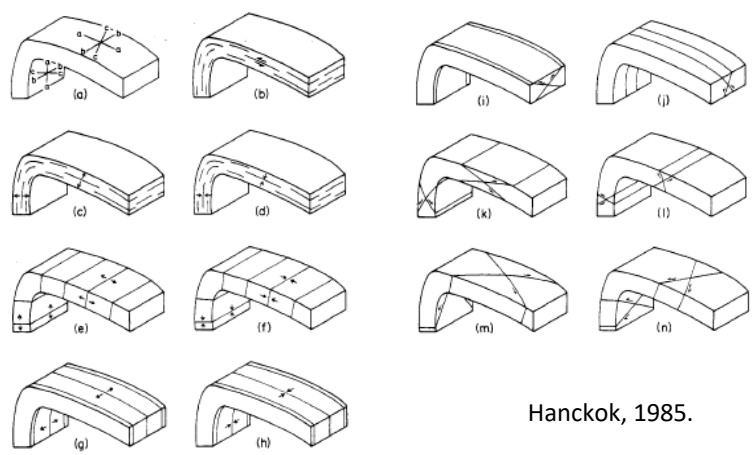
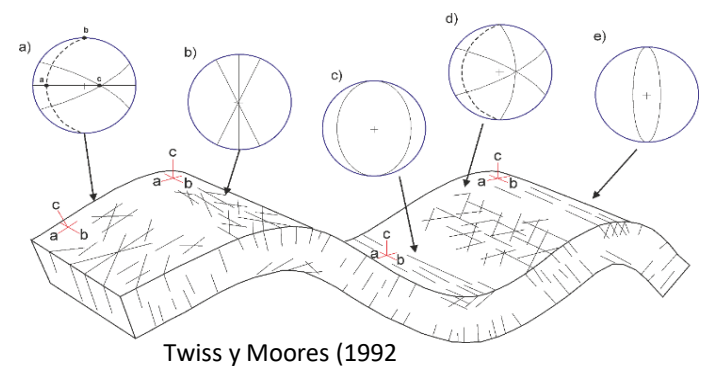
Acoculco Fault





# What about the fracturing?

- On the oldest rocks we can see the fracture network that was generated in different stages.
- High percentage of those fractures have been sealed by minerals or metamorphism, except recent fractures.
- That's why it's important to separate the old fracturing from the neoformed.



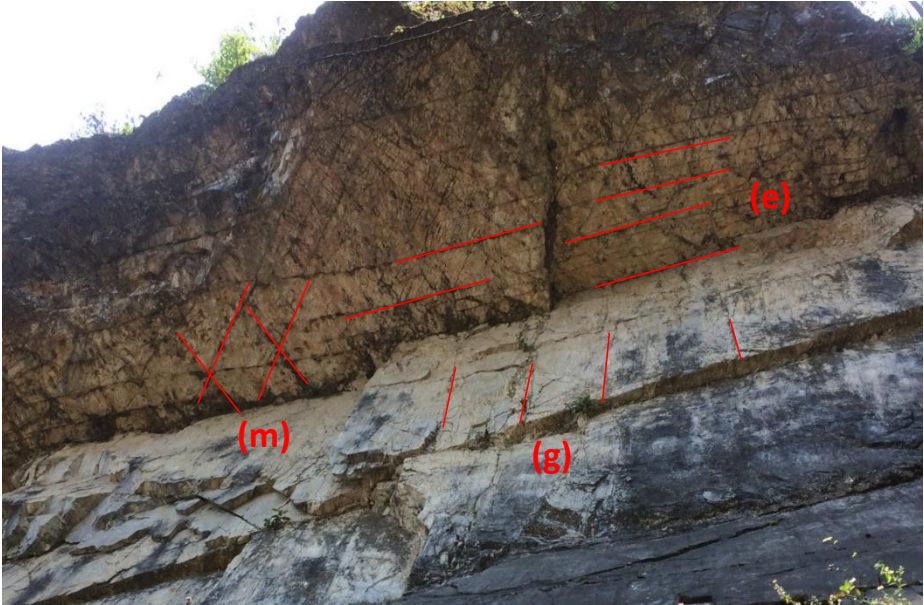
(j) (c)



(e) (l)



(b)



(e) (m) (g)

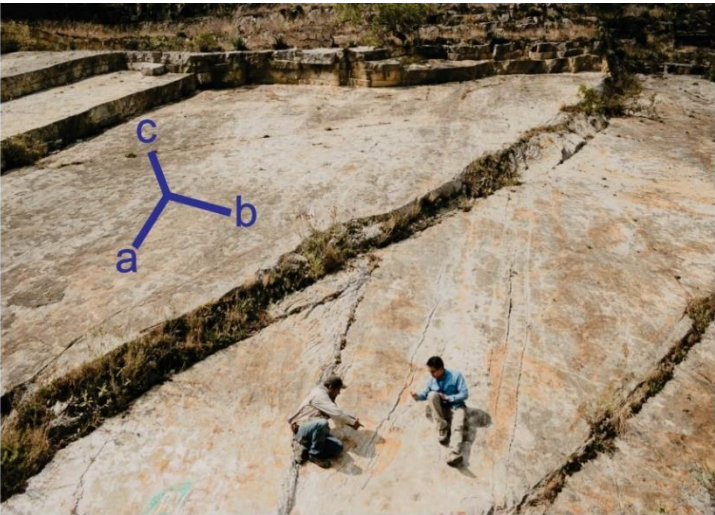


(m)



# Metodology

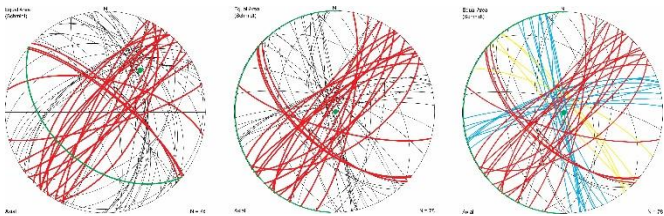
Measure the bedding and identified the 3 principal axes



Identify the relative chronology of fractures



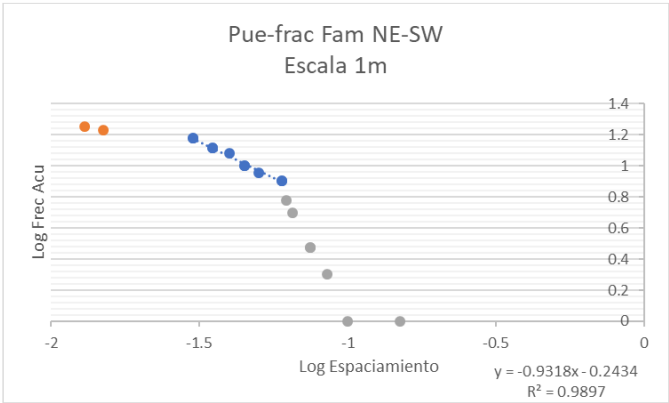
Plot and rotate the data



Analysis 1D based on power law's



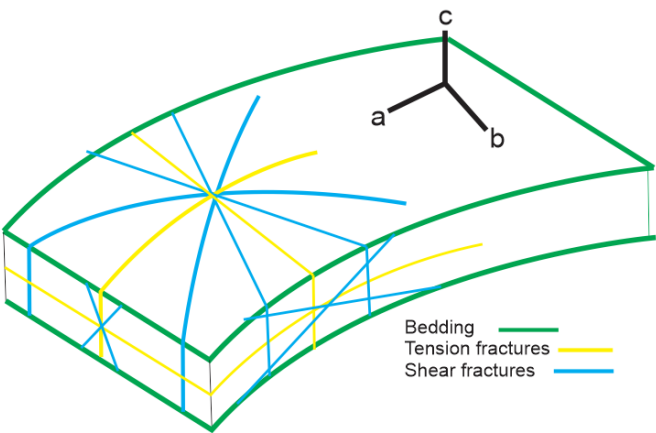
Scane line 1m



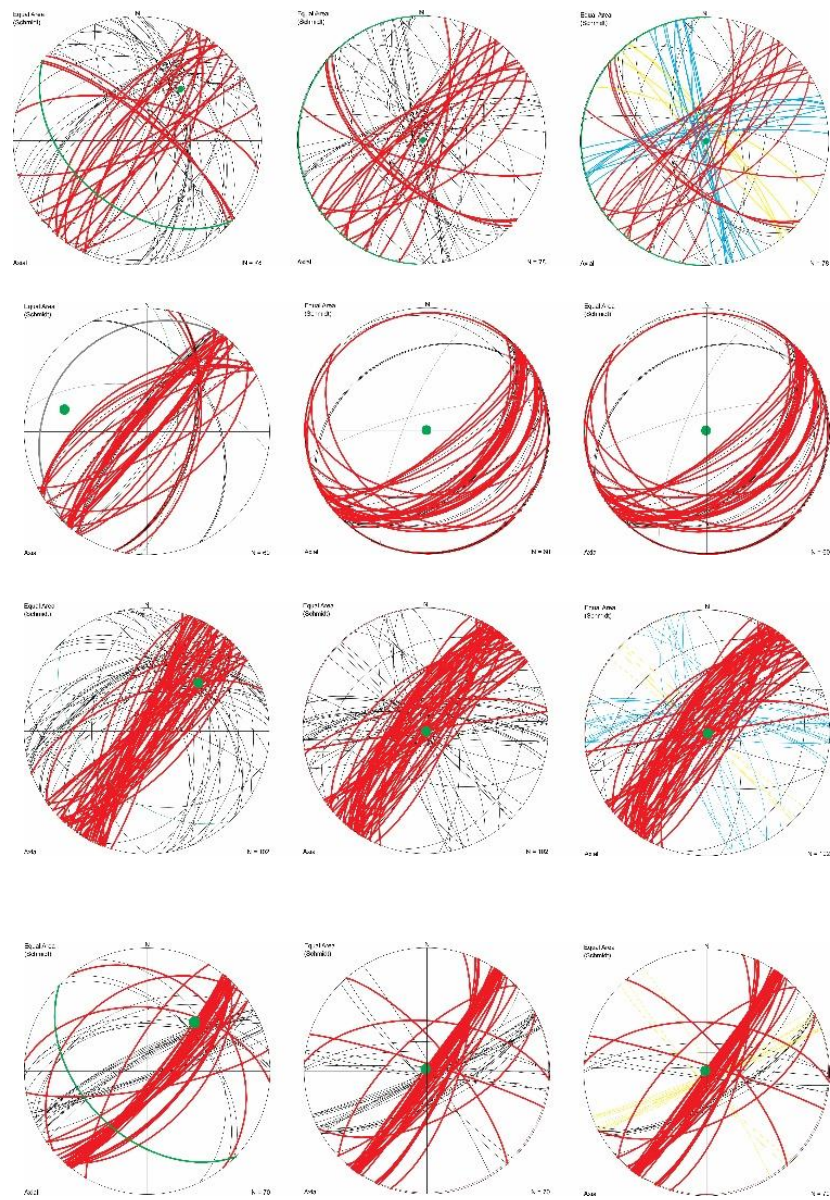
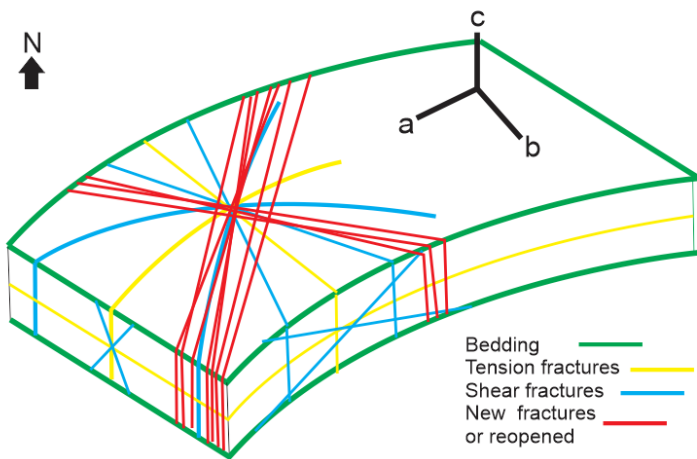


# Results of statistical analysis

3 set's of tension fractures  
3 set's of shear fractures

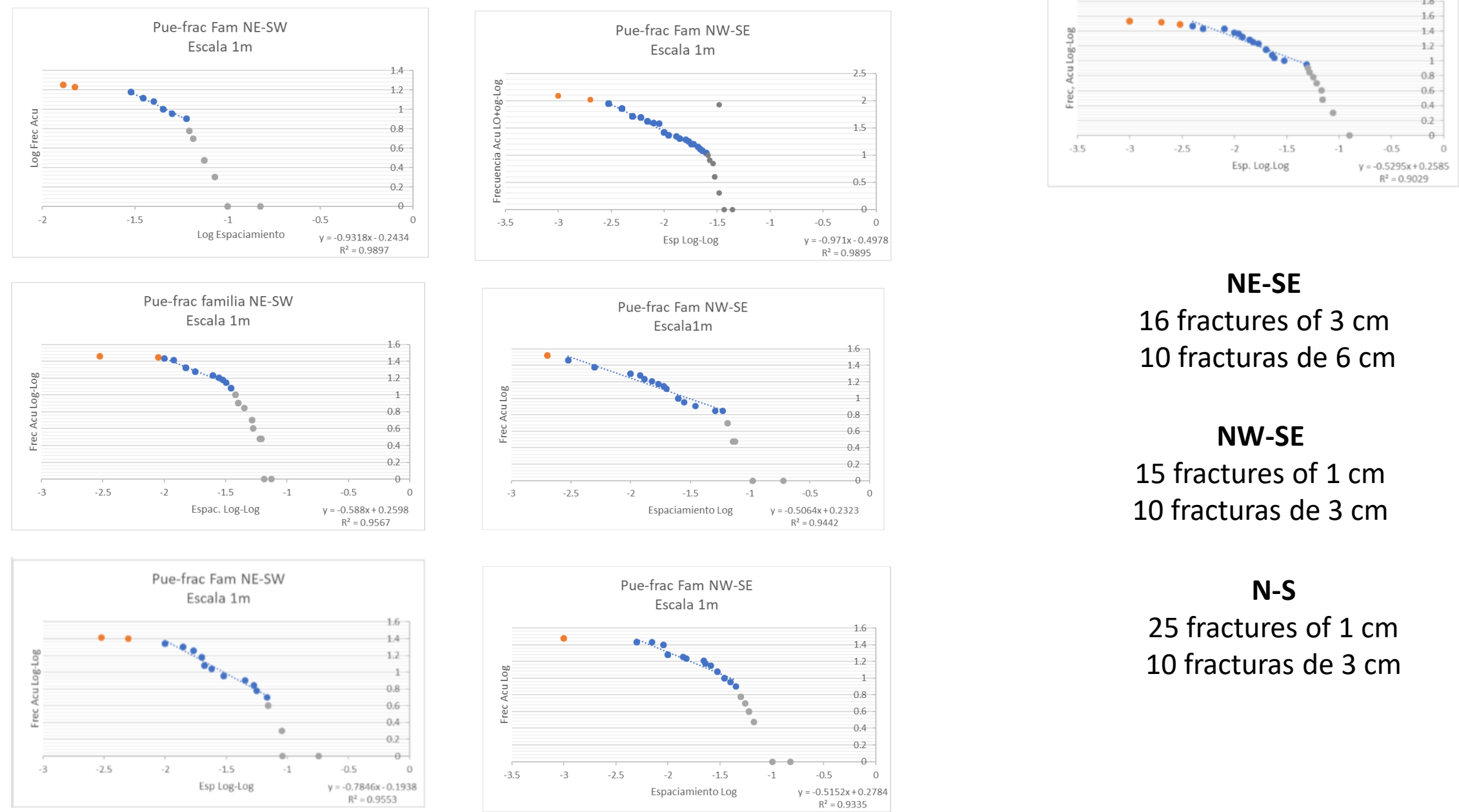


2 Set's of new fractures or reopened





The statistical analysis was done for 3 sets o fractures, the results shows a good fit.  
The correlation index is near to 1.0.



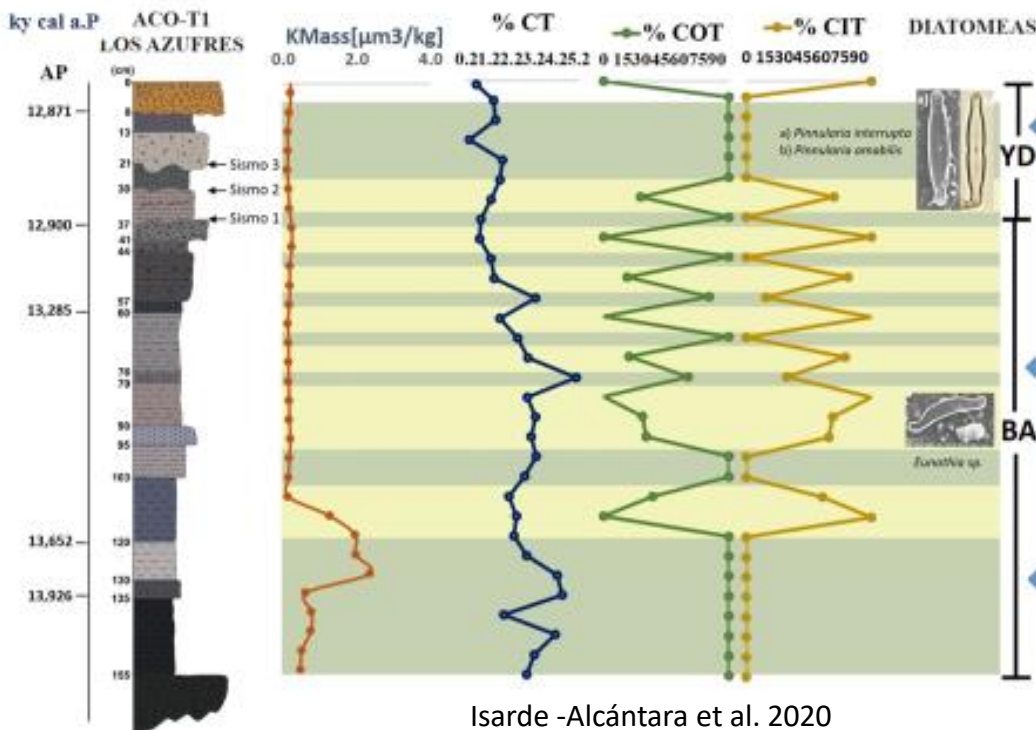
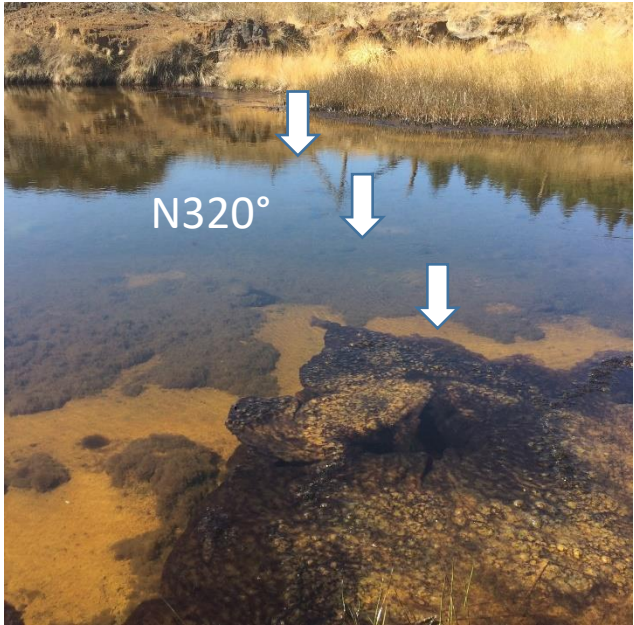
**NE-SE**  
16 fractures of 3 cm  
10 fracturas de 6 cm

**NW-SE**  
15 fractures of 1 cm  
10 fracturas de 3 cm

**N-S**  
25 fractures of 1 cm  
10 fracturas de 3 cm



Another evidence of the presence of newfractures



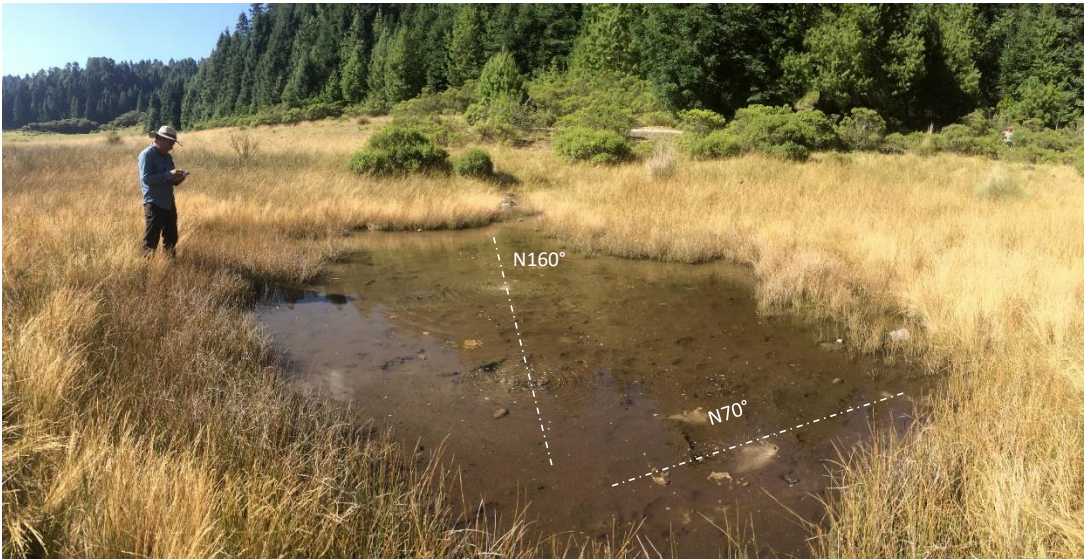
Post-12,000 años. Se establece actividad hidrotermal constante

De 12. 700 a 12,900 lago de aguas diluidas, pero frías, con mayor influencia hidrotermal en paralelo con la reactivación de la sismicidad

De 12,900 a 13,600. Por 700 años el la fue muy fluctuante con pequeños puls de hidrotermalismo (caolinita asociada)

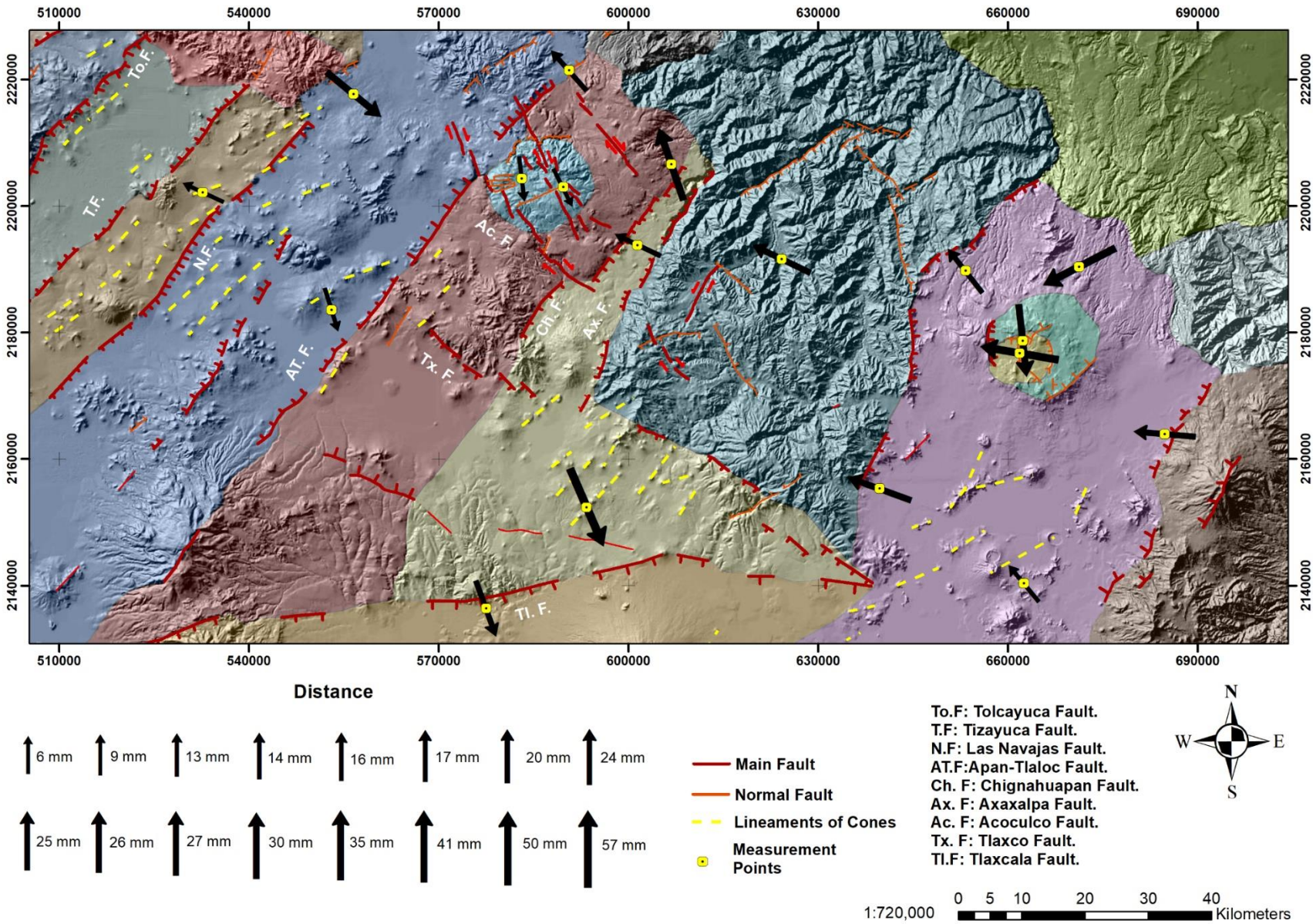
De 13,600 a 14,000 años se observa un pantano de aguas frías diluidas, clima húmedo con escaso hidrotermalismo

Isarde -Alcántara et al. 2020



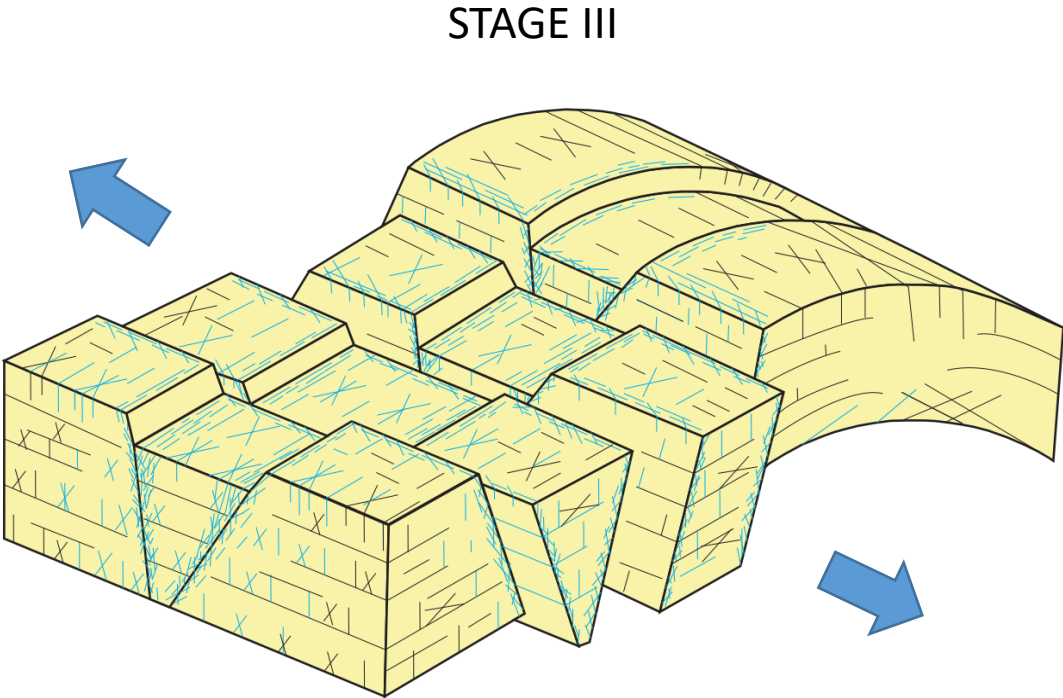
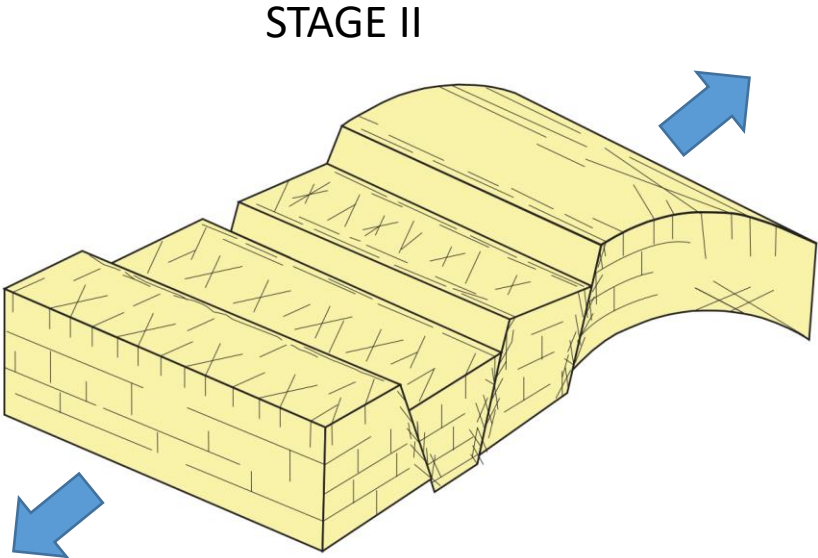
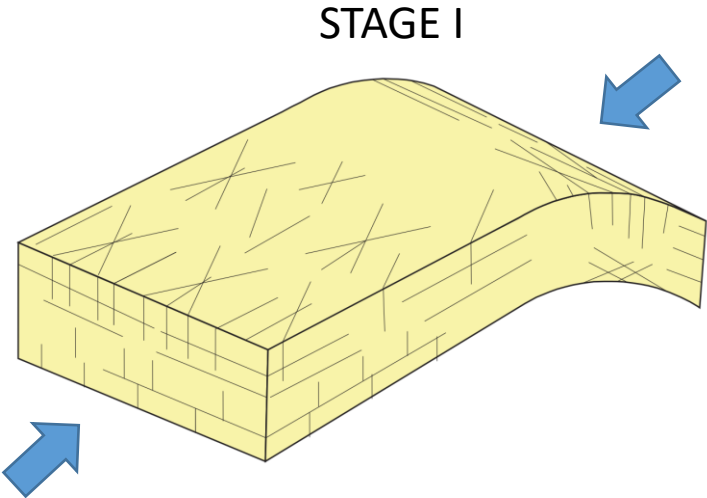


Another evidence of the stress field still active





Deformation of sedimentary basement





## CONCLUSIONS

- The analysis of fractures and faults in the sedimentary units of the Chignahuapan horst, are a good analogue for the study of the neofracturing of the rocks that house the geothermal system in the Acoculco caldera.
- The results show that the area is under an extensive current stress field of NW-SE orientation.
- This stress field facilitates the creation or reopening fractures in the NE-SW direction
- The fractures that will be reopened are those located close to fault zones where there is a greater concentration of stresses
- NW-SE fractures will be more likely to reopen
- Based on the fracturing schematic model obtained with respect to the main structures of the area, the area with the most fracture density is at the north of the wells in the hanging wall of the NE-SW fault in the intersection of the NW-SE fault zone.
- The fracturing analysis has to be performed on a larger scale
- Three systems of fractures related to folding can be reopened: Tension fractures ac and bc shear fractures HK0 - a



