California
Department of Conservation
California Geological Survey

Minimum Standards for Digital Active Fault Mapping at CGS

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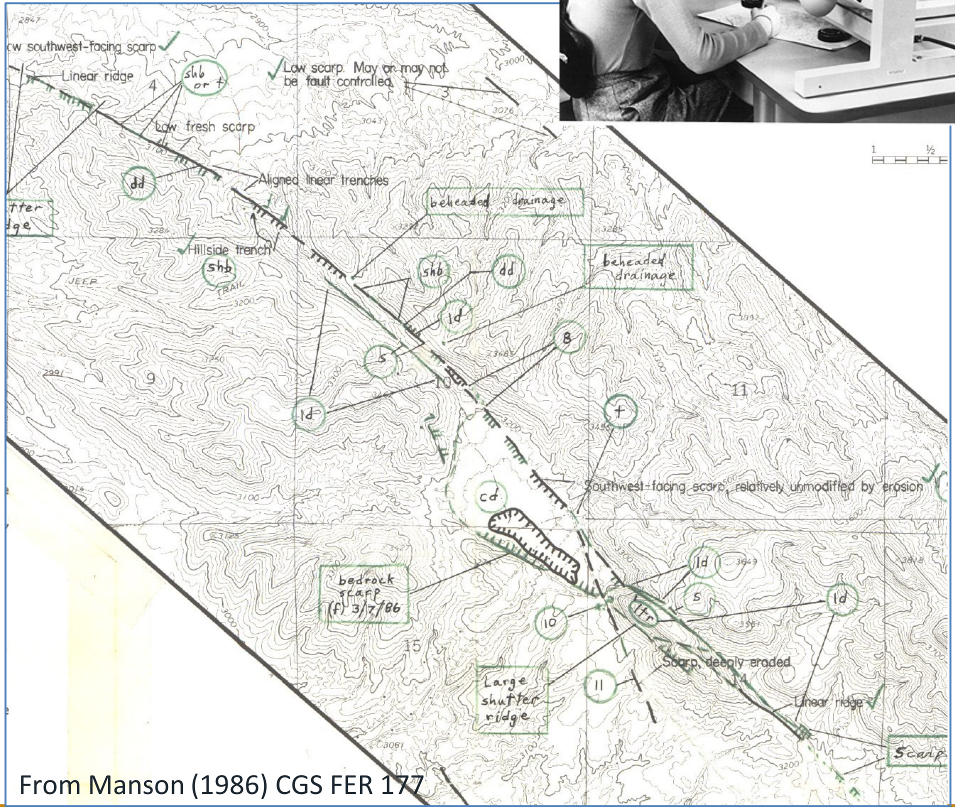
Legacy Fault Mapping

1970s – 1990s CGS Active Fault Mapping

- Utilized available aerial imagery. Scales varied from 1:20k-scale to >1:5k-scale aerial photos.
- Air photo mapping was transferred from photos to a base map using Zoom Transfer Scopes – registered images (air photos) to base maps via a optical/mechanical device.
- Locational accuracy ideally would match that of the USGS topographic base map – features located within 40 feet (12 meters) of actual position.

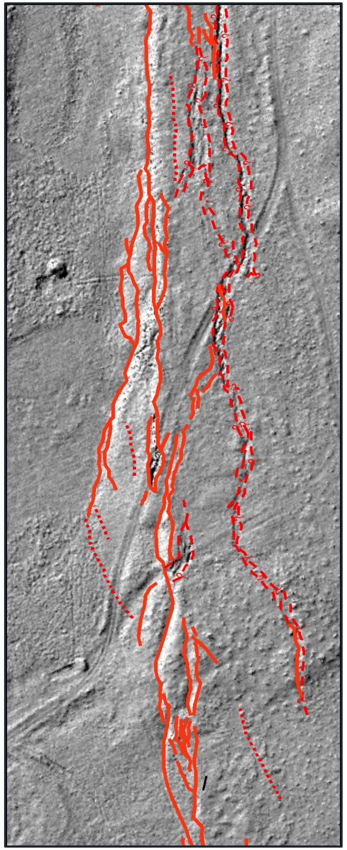


From Manson (1986) CGS FER 177

Current Fault Mapping

- Availability of digital, georeferenced high-resolution imagery and lidar allows for large-scale, detailed mapping with exceptional spatial precision.

- Mapping scale dependent on type of imagery, imagery resolution, time and budget constraints.



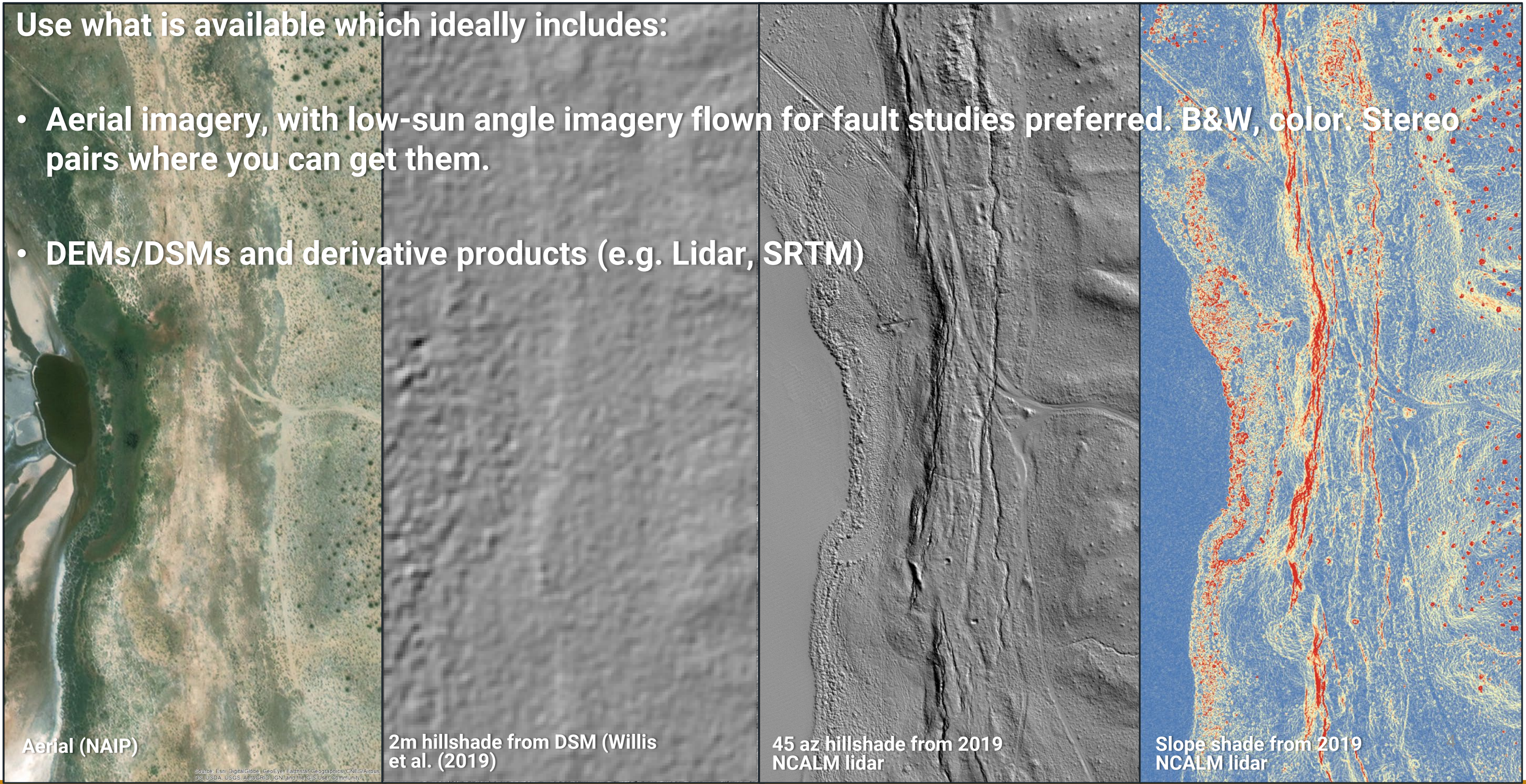
CGS (in progress)
1:1000 scale mapping

Pierce et al. (2020)
1:40 – 1:150 scale mapping

Types of Imagery Typically Used in Fault Evaluations

Use what is available which ideally includes:

- Aerial imagery, with low-sun angle imagery flown for fault studies preferred. B&W, color. Stereo pairs where you can get them.
- DEMs/DSMs and derivative products (e.g. Lidar, SRTM)



Locational Accuracy and Scientific Confidence

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- Terms come from USGS geologic mapping standards (See Soller et al. (2002) – USGS OFR 02-370)

Scientific confidence:

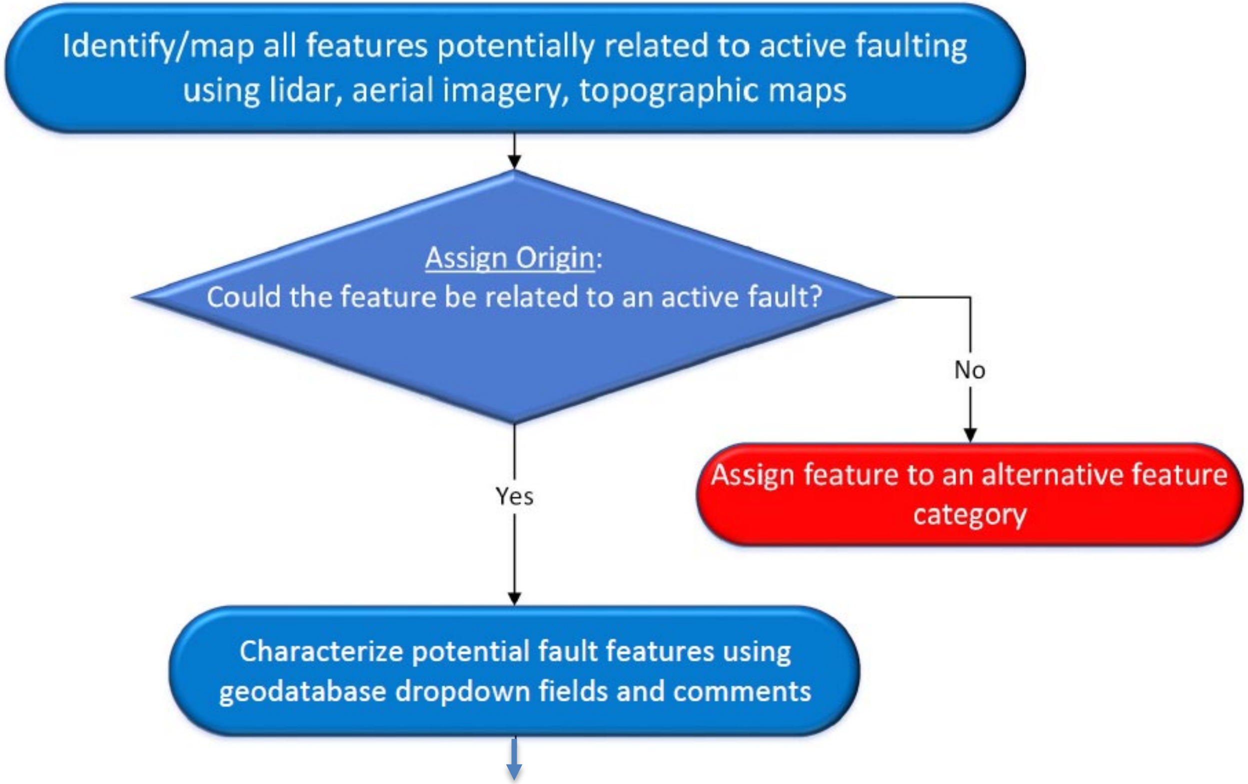
  - Identity: What is the feature?
  - Existence: How confident are we what it is?

- Locational accuracy: Can I plot with feature accurately?
- <u>Inferred</u> and <u>concealed</u> categories are more interpretive.

Symbol	Scientific confidence	Examples
——————— — — — — — - - - - - - - - - -	Identity and Existence certain	*"I am certain that the planar feature I see in this outcrop is a fault."*
———?——— — — ? — — - - ? - - ? - - ? - - .....?.....?.....?.....	Identity or Existence questionable	*"I can see some kind of planar feature in this outcrop, but I can't be certain if it's a contact or a fault."*

Symbol	Locational accuracy	Examples
———————	accurately located	*"I can clearly see this contact in outcrop, and can accurately plot its position on the map."*
— — — — —	approximately located	*"I can see this contact in outcrop, but the poor quality of my base map prohibits me from accurately plotting its position."*
- - - - - - - - - -	inferred	*"I can see by the change in debris materials visible around these gopher holes that a contact runs through here, but I can't locate it very precisely."*
....	concealed	*"I can see that a contact is present on both sides of this lake, but I can't tell where it is located beneath the water."*

Typical CGS Workflow for Active Fault Mapping



Typical CGS Workflow for Active Fault Mapping

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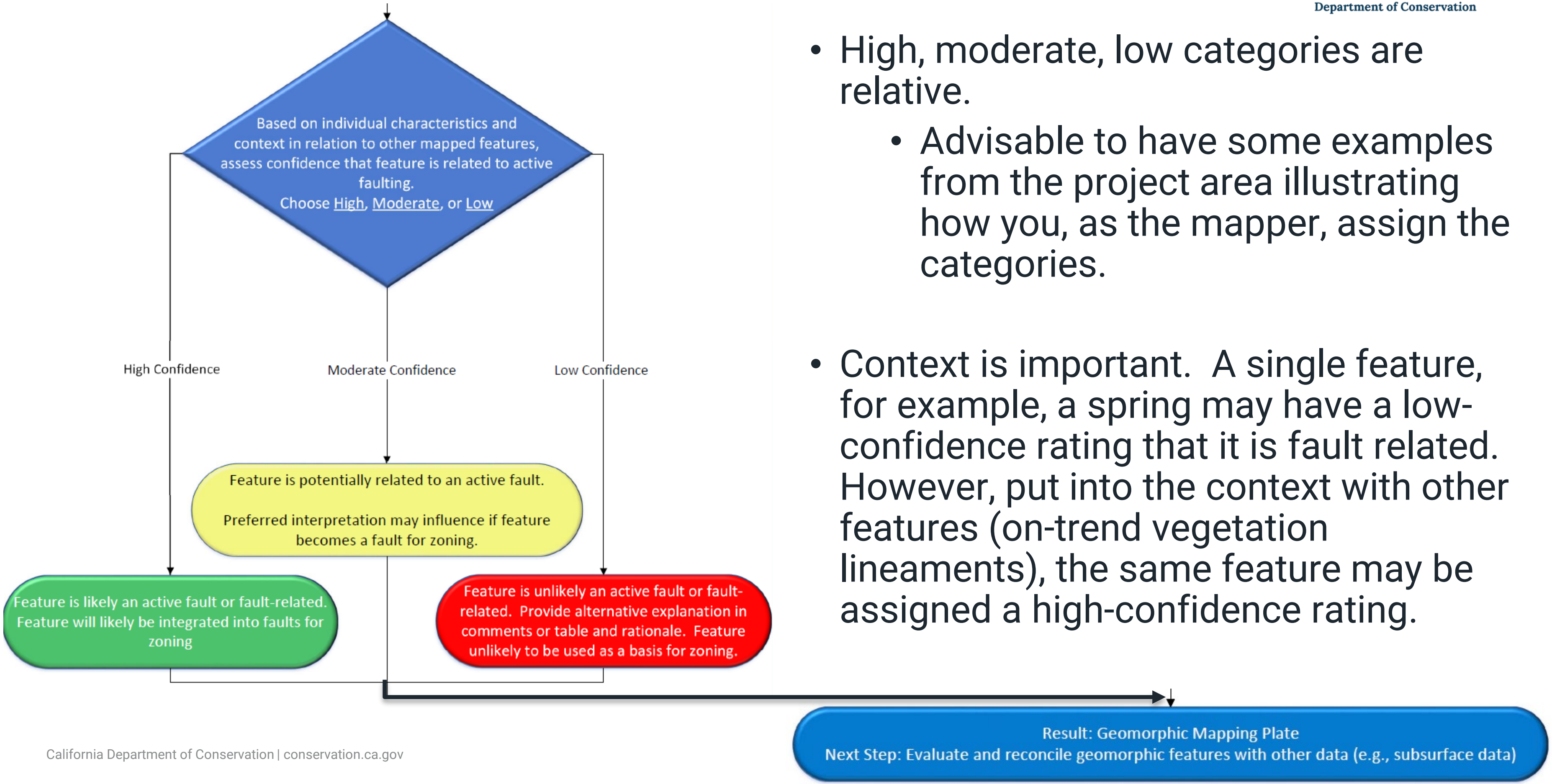


- High, moderate, low categories are relative.
  - Advisable to have some examples from the project area illustrating how you, as the mapper, assign the categories.
- Context is important. A single feature, for example, a spring may have a low-confidence rating that it is fault related. However, put into the context with other features (on-trend vegetation lineaments), the same feature may be assigned a high-confidence rating.

Geodatabase Schema

- Geodatabase can be as simple or as complex as desired. The level of complexity depends on what the geodatabase will be used for and should consider what is practical in terms of time and effort to populate. Fields with specified values typically reserved for DB queries and symbology.

Type	Specifies the kind of feature represented by the line. For example, "fault", ”scarp” “vegetation lineament", “linear ridge", etc. Can be populated with dropdown values. Nulls not permitted
Location Confidence	Half-width in meters of positional uncertainty envelop; position is relative to other features in database. Null values not permitted. Recommend value of -9 if value is not available. Suggested distances qualitatively described in "Feature-level metadata" document
Existence Confidence	Values = "certain", "questionable", "unspecified". Null values not permitted. Suggest setting default value to "certain"
Identity Confidence	Values = "certain", "questionable", "unspecified“. Alternative: “High”, Moderate”, “Low”. Null values not permitted. Suggest setting default value to "certain"
Data Source	Imagery used for interpretation, e.g. NCALM lidar, NAIP, 1:5,000 airphotos
Mapping scale	Mapping scale of either linework, or project (if set mapping scale used).
Comments	Optional. Free text for additional information specific to this feature. Null values permitted.
Mapper	Name of mapper
Mapper Affiliation	Affiliate of mapper, commonly recognized abbreviations (e.g. CGS, USGS, UNR) acceptable.

Feature Classes

What feature class to use is often scale-dependent.

- Lines: Linear features such as faults, tonal lineaments, linear valleys, deflected drainages

- Points: Smaller features such as springs, saddles, small depressions, places that you want to annotate with a comment

- Polygons: Larger features such as pull-apart basins, triangular facets, linear ridges/pressure ridges, offset surfaces.

Attribute fields

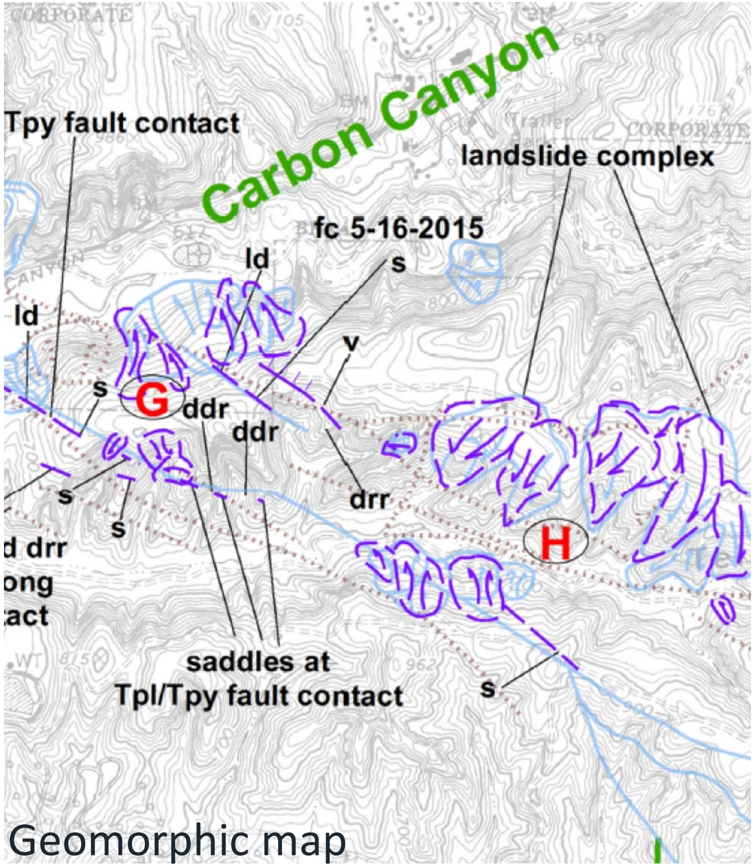
ArcGIS (not sure about QGIS) has the ability to have dropdown lists in the attribute fields that help enforce consistence and aids in filling out attributes.

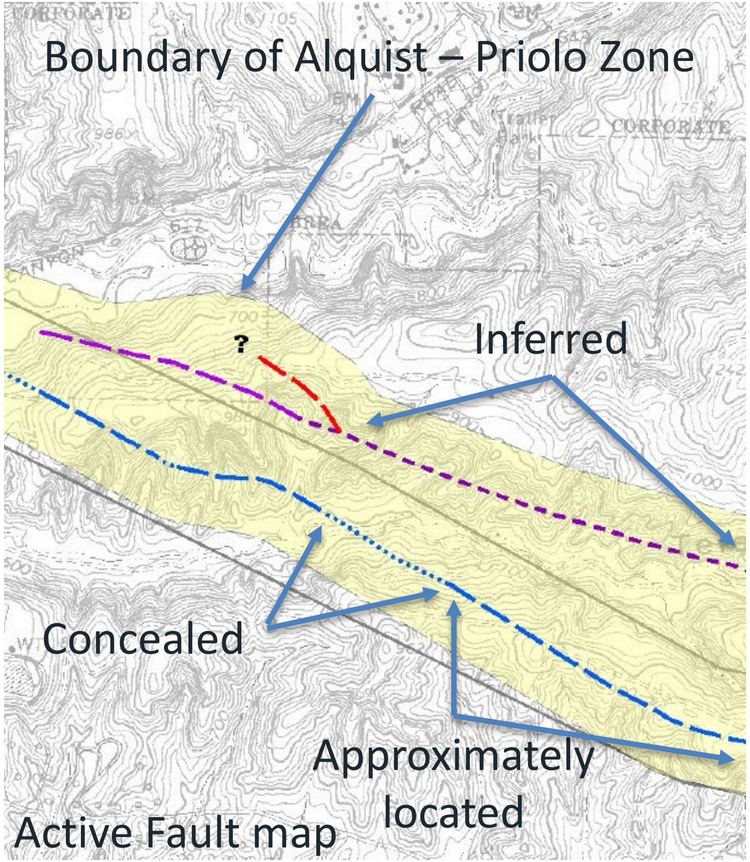
Some examples of what CGS uses:

- Type (Origin)

- Feature type Dropdown list
- Uphill-Facing Scarp
- Beheaded Drainage
- Break in Slope
- Closed Depression
- Deflected Drainage, left lateral
- Deflected Drainage, right lateral
- Drainage Knickpoint
- Faceted Spur
- Linear Drainage
- Linear Trough
- Notch
- Offset Cultural Feature
- Ponded Alluvium
- Pressure Ridge
- Offset Ridge, left lateral
- Offset Ridge, right lateral
- Saddle
- Scarp
- Shutter Ridge
- Side-Hill Bench
- Spring
- Swale
- Tonal Lineament
- Trough
- Vegetation Lineament
- Sag Pond
- Mole Track
- Linear Front
- Offset Drainage, right lateral
- Offset Drainage, left lateral

Example of CGS FER geomorphic map and A-P Zone map





From Hernandez (2017) CGS FER 258