







This new geologic map is an important contribution. The overall layout is beautifully done and the basement mapping is superb in general. Similarly, the addition of Robertson's landslide mapping is important as that is now in a much more accessible digital format. Showing the Frenchman Mountain is also an important step forward that should be duplicated throughout Grand Canyon. However, there are some portions of the mapping that seem unfinished, particularly the database but also the fault and surficial mapping, which could be improved in a number of places. Although, I understand that certain surficial units are omitted to highlight the bedrock (e.g. talus) those that are shown should be shown consistently. There are many instances where important travertine, debris fan, and Colorado River gravel deposits are omitted despite being shown in other areas of the map. I have also found places where faults seem to be mislocated or missing. When comparing this map to our in-progress Grand Canyon 30' x 60' I see pros and cons to each. Ultimately merging the two would ultimately serve the end user as their scales are not that dissimilar. Digitally the map is far from perfect. I have not focused on adherence to strict GeMS or FDGC compliance (I don't think there is metadata at all) as that is not a requirement of the publication venue or the funding agency. I don't think that should be required since the mapping was done by non-USGS academic mappers. Instead of focusing on the GeMS and metadata, I have looked for logical inconsistencies and issues that might hamper the end user's ability to use the database. For example, there are files (layer files) that reference spatial data (feature classes or rasters) that don't exist. The symbology also does not include mapunit names for about a quarter of the units, which would make the user refer back to a different table or file. There are also gaps in the mapping where polygons with no attributes exist and multiple locations where polygons were given the wrong attribution (map unit). The Watahomigi (IPwa) is shown as only Pennsylvanian, while recent work (see Billingsley maps) indicates it is also locally Mississippian. Inconsistently the undivided lower Supai includes the Mississippian at least in the mapunit abbreviations (i.e. IPMs and QlsMPu). QlsMPu should be QlsIPMu; the unit is not Permian and the Eras should be consistently listed youngest to oldest or oldest to youngest. IPMs is shown on the map 11 times but is not listed in the Explanation of Map Units on Plate 1 or in the DMU non-spatial table; similar for QlsCba. What follows is a more complete list of the types of issues in the map with some examples; by no means have I detailed all the errors. I also provide some comments on the layout mostly related to the geologic names. The authors use some names not in Geolex but have very good reasons for doing so and such names have been used throughout the literature including in some cases on USGS geologic maps. More than them being non-compliant, Geolex is out of date. I also looked that the supplemental tables and they seem to be in good order. The only







































thing I saw were some names issues is DR5 – Bass Rapids and Garnet dike swarm. These don't need to be USGS data releases or have metadata since I understand them to not have been collected by the USGS author.

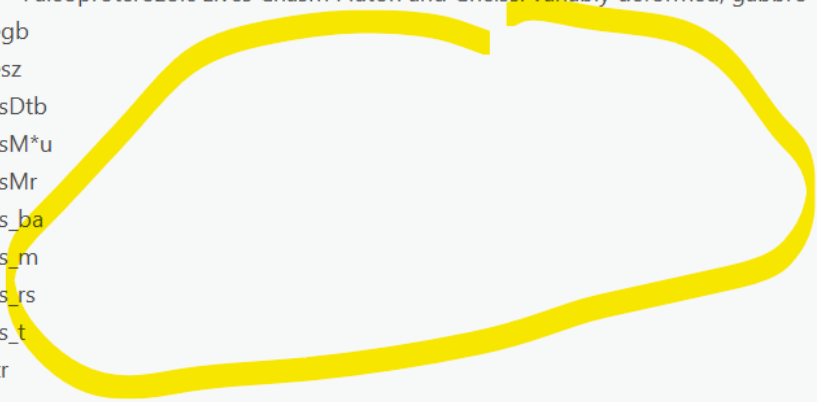
- **Layer files for river miles and DRGs are provided but the associated feature classes are not in the database**
- **In the Polygons feature class label all the mapunits and remove references to special fonts that don't display properly there (this also created problems because those special symbols are not in the DMU non-spatial table).**

☑ MiddleGorgePolys_20260122

Label

-  Water
-  Qc - Quaternary Colluvium
-  Qal - Quaternary alluvium
-  Qgt 
-  Qls - Quaternary landslides

-  Dtb - Devonian Temple Butte Limestone
-  Qlsp - Quaternary Paludal Facies in headscarp basins
-  Ph - Permian Hermit Shale
-  Pt - Permian Toroweap Formation
-  Pc 
-  Pk - Permian Kaibab Limestone
-  *Ms - Wescogame, Manakacha and Watahomigi Formation, undivided
-  *mw - Pennsylvanian Wescogame and Manakacha formations of the Supai Group, Undivi...
-  *wa - Pennsylvanian Watahomigi Formation of the Supai Group
-  Pe - Pennsylvanian Esplanade Sandstone of Supai Group
-  Mr - Mississippian Redwall Limestone
-  _m - Cambrian Muav Formation
-  _ba - Cambrian Bright Angel Formation
-  _t - Cambrian Tapeats Sandstone
-  Yi - Diabase intrusives of the Unkar Group
-  Yd - Dox Formation of the Unkar Group
-  Ys - Shinumo Quartzite of the Unkar Group
-  Yh - Hakatai Shale of the Unkar Group
-  Yb - Bass Limestone of the Unkar Group
-  Xg - Paleoproterozoic granites - Dikes, aplites, and granitic bodies related to D2 tectonis...
-  Xgd - Paleoproterozoic granodiorite complexes: gabbro-diorite-granodiorite intrusions, i...
-  Xv - Precambrian Vishnu Schist: quartz-mica schist, pelitic schist, meta-arenites of turbiditi...
-  Xb - Paleoproterozoic Brahma Schist: amphibolite, biotite-hornblende schist and biotite s...
-  Xr - Paleoproterozoic Rama Schist and Gneiss: Quartzofelspathic schists and gneisses of v...
-  Xe - Paleoproterozoic Elves Chasm Pluton and Gneiss: variably deformed, gabbro-diorite-...
-  Xegb
-  Xesz
-  QlsDtb
-  QlsM*u
-  QlsMr
-  Qls_ba
-  Qls_m
-  Qls_rs
-  Qls_t
-  Qtr
-  _fm
-  <all other values>



RSA

- Remove unused symbols from CAF and GeologicLines
- Remove dates from feature class names (i.e. MiddleGorgePolys_20260122) – should be called MiddleGorgeMapUnitPolygons
- You should wipe the processing history from your embedded metadata – this may be security risk as it includes absolute paths to files on your servers and computers

Process

Date 2023-02-27 09:11:19

Tool location c:\users\jmbai\appdata\local\programs\arcgis\pro\Resources\ArcToolbox\Toolboxes\Data Management Tools.tbx\Rename
Command issued

```
Rename "C:\Users\jmbai\OneDrive - University of New Mexico\MS_Thesis\GIS\LowerGorgeMap\Work\GRCA_LwrGrg_Basement\GRCALowerGorge.gdb\LowerGorgeGeologicMap\Lower "C:\Users\jmbai\OneDrive - University of New Mexico\MS_Thesis\GIS\LowerGorgeMap\Work\GRCA_LwrGrg_Basement\GRCALowerGorge.gdb\LowerGorgeGeologicMap\Lower FeatureClass
```

Include in lineage when exporting metadata No

Process

Date 2023-02-28 12:34:39

Tool location c:\program files\arcgis\pro\Resources\ArcToolbox\Toolboxes\Data Management Tools.tbx\Rename
Command issued

```
Rename "C:\Users\jbailey06\OneDrive - University of New Mexico\MS_Thesis\GIS\LowerGorgeMap\Work\GRCA_LwrGrg_Basement\GRCALowerGorge.gdb\LowerGorgeGeologicMap\Lower "C:\Users\jbailey06\OneDrive - University of New Mexico\MS_Thesis\GIS\LowerGorgeMap\Work\GRCA_LwrGrg_Basement\GRCALowerGorge.gdb\LowerGorgeGeologicMap\Lower FeatureClass
```

Include in lineage when exporting metadata No

Process

Date 2023-02-28 12:49:23

Tool location c:\program files\arcgis\pro\Resources\ArcToolbox\Toolboxes\Data Management Tools.tbx\UpdateSchema
Command issued

```
UpdateSchema "CIMDATA=<CIMFeatureDatasetDataConnection xsi:type='typens: CIMFeatureDatasetDataConnection' xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance' xmlns:xs='http://www.w3.org/2001/XMLSchema' xmlns:typens='http://www.esri.com/schemas/ArcGIS/3.0.0'> <FeatureDataset>LowerGorgeGeologicMap</FeatureDataset> <WorkspaceConnectionString>DATABASE=C:\Users\jbailey06\OneDrive - University of New Mexico\MS_Thesis\GIS\LowerGorgeMap\Work\GRCA_LwrGrg_Basement\GRCALowerGorge.gdb</WorkspaceConnectionString> <WorkspaceFactory>FileGDB</WorkspaceFactory><Dataset>LowerGorgeMapUnitLabelPoints</Dataset> <DatasetType>esriDTFeatureClass</DatasetType></CIMFeatureDatasetDataConnection>" <operationSequence> <workflow><AddField><field_name>methodid</field_name><field_type>TEXT</field_type> <field_length>255</field_length><field_alias>MethodID</field_alias> <field_is_nullable>True</field_is_nullable><field_is_required>False</field_is_required> <field_domain>MethodID</field_domain></AddField></workflow></operationSequence>
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Include in lineage when exporting metadata No

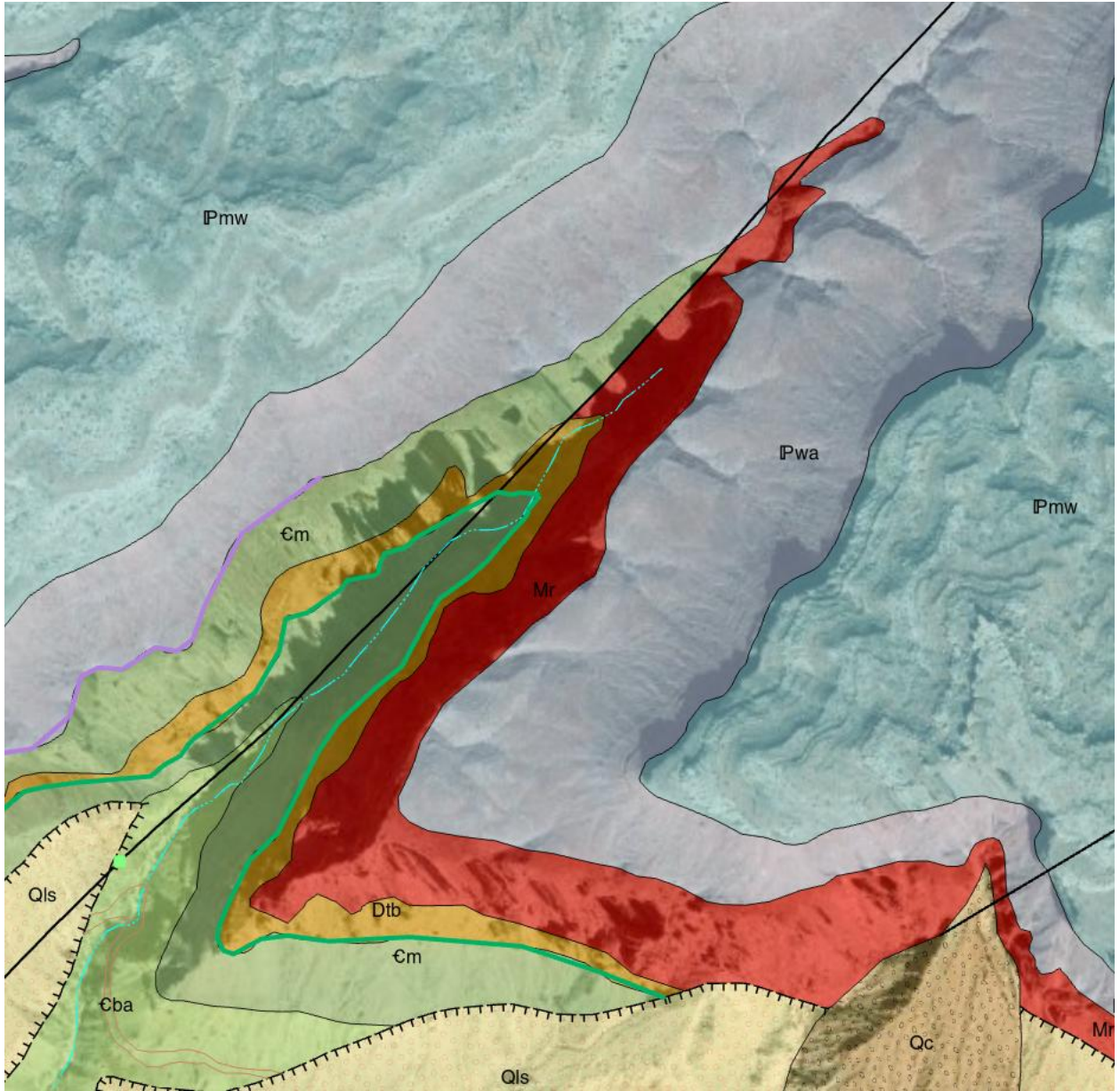
Process

Date 2023-06-19 14:15:32

Tool location c:\users\jmbai\appdata\local\programs\arcgis\pro\Resources\ArcToolbox\toolboxes\Data Management Tools.tbx\CalculateField

Command issued

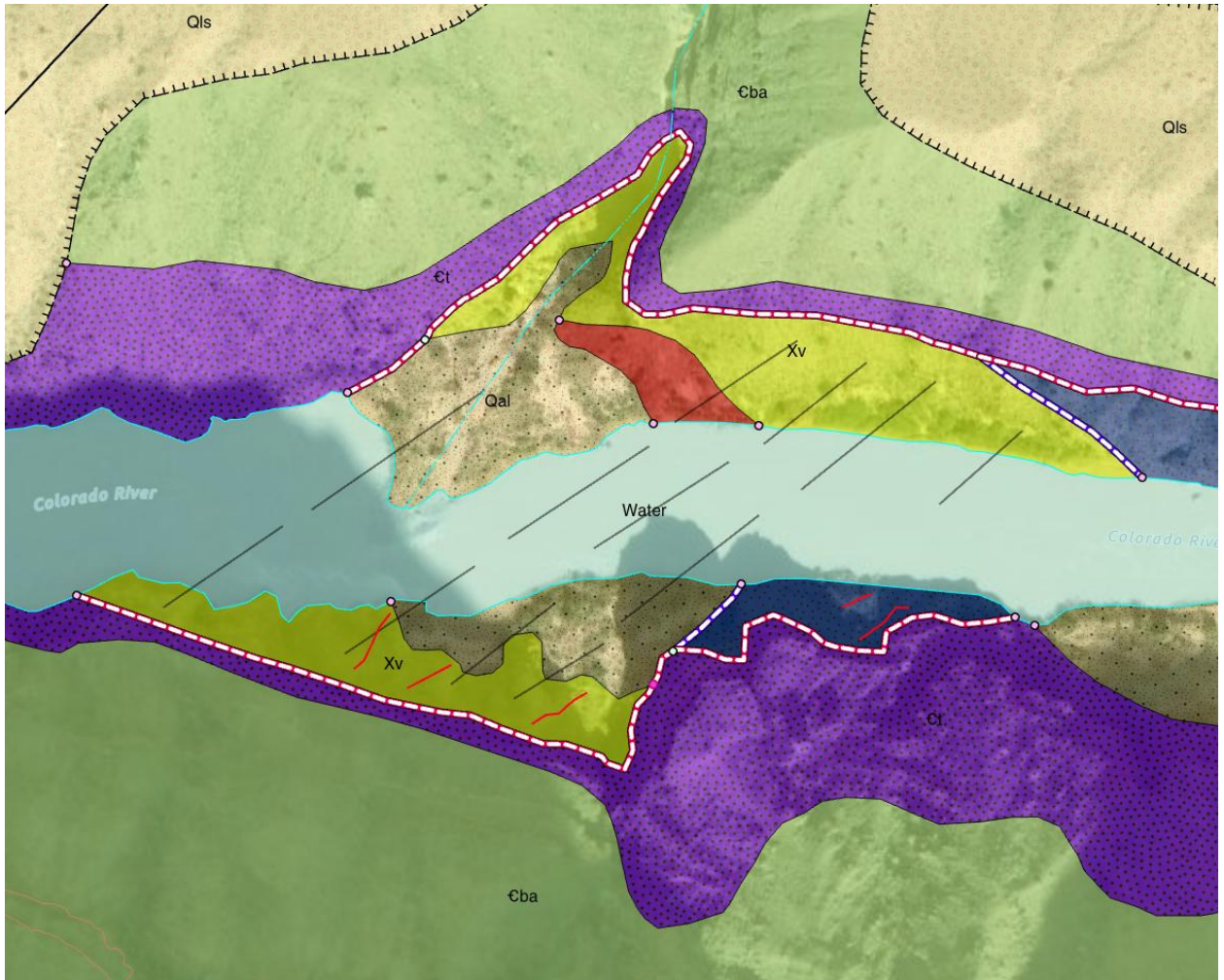
- You have a polygon labeling issue in the NW corner of the map where Cm should be Mr



- **Overlay polygons do not always match CAF**

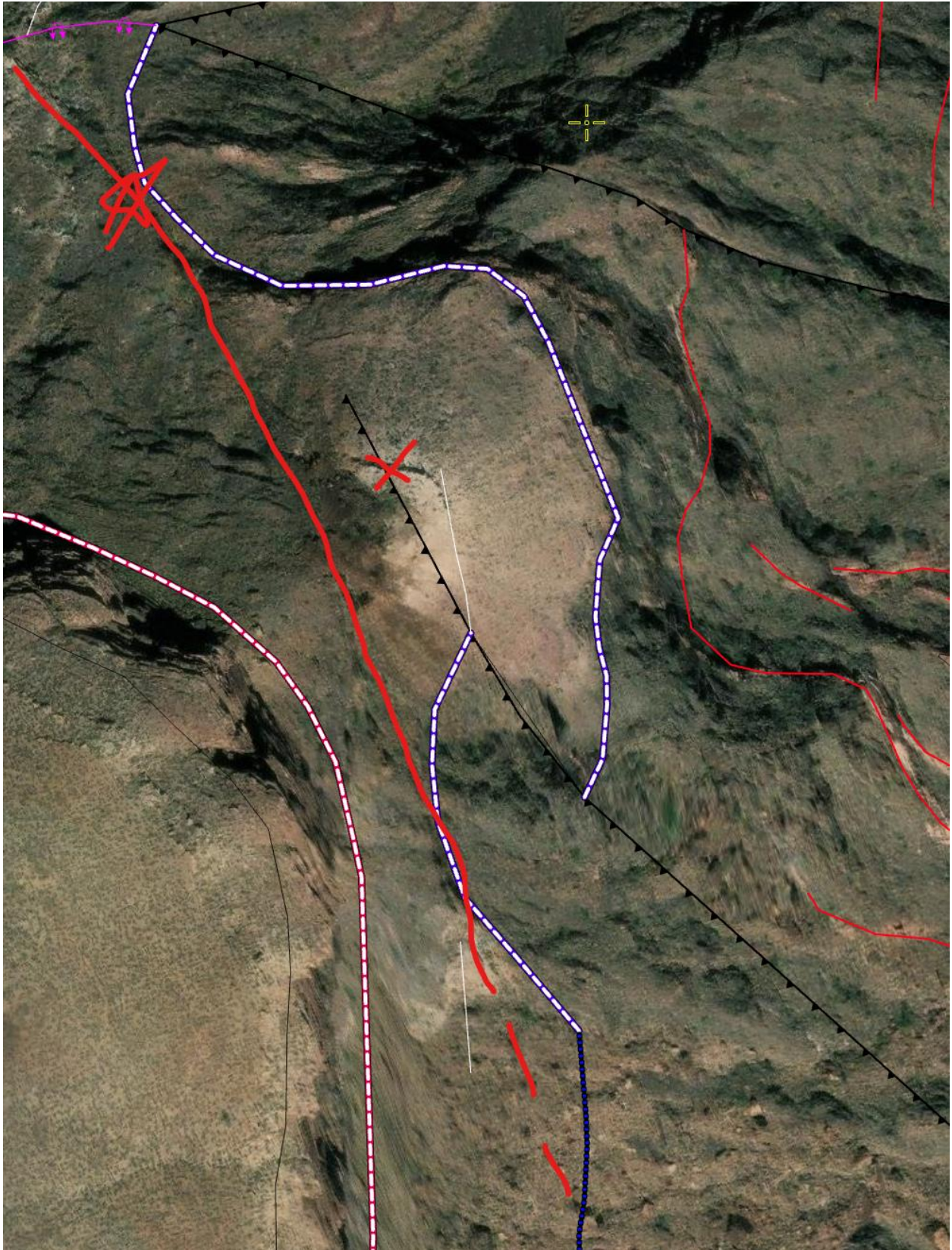


- **Great Unconformity is shown between Q and Ct**



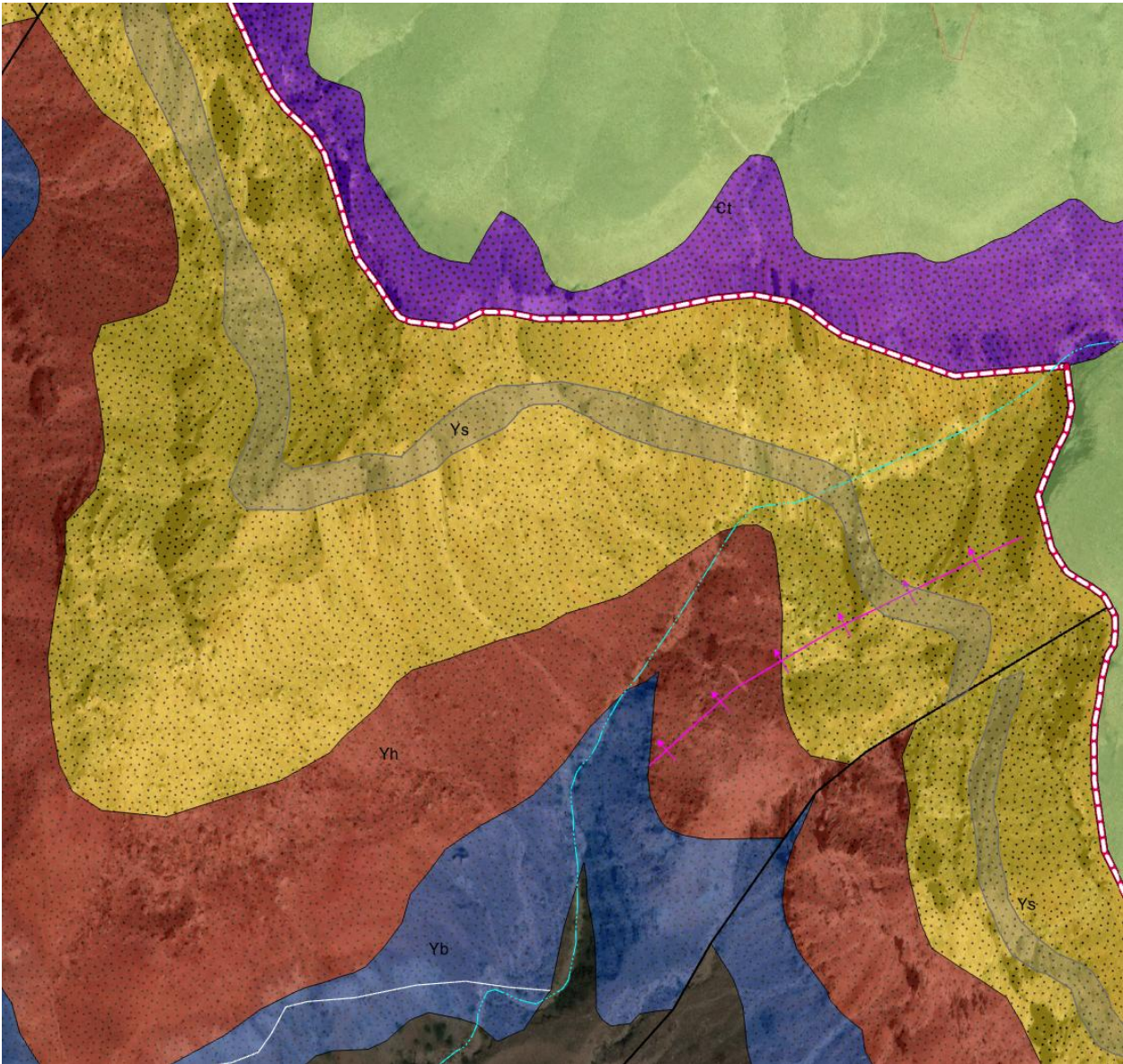
Many more examples of this

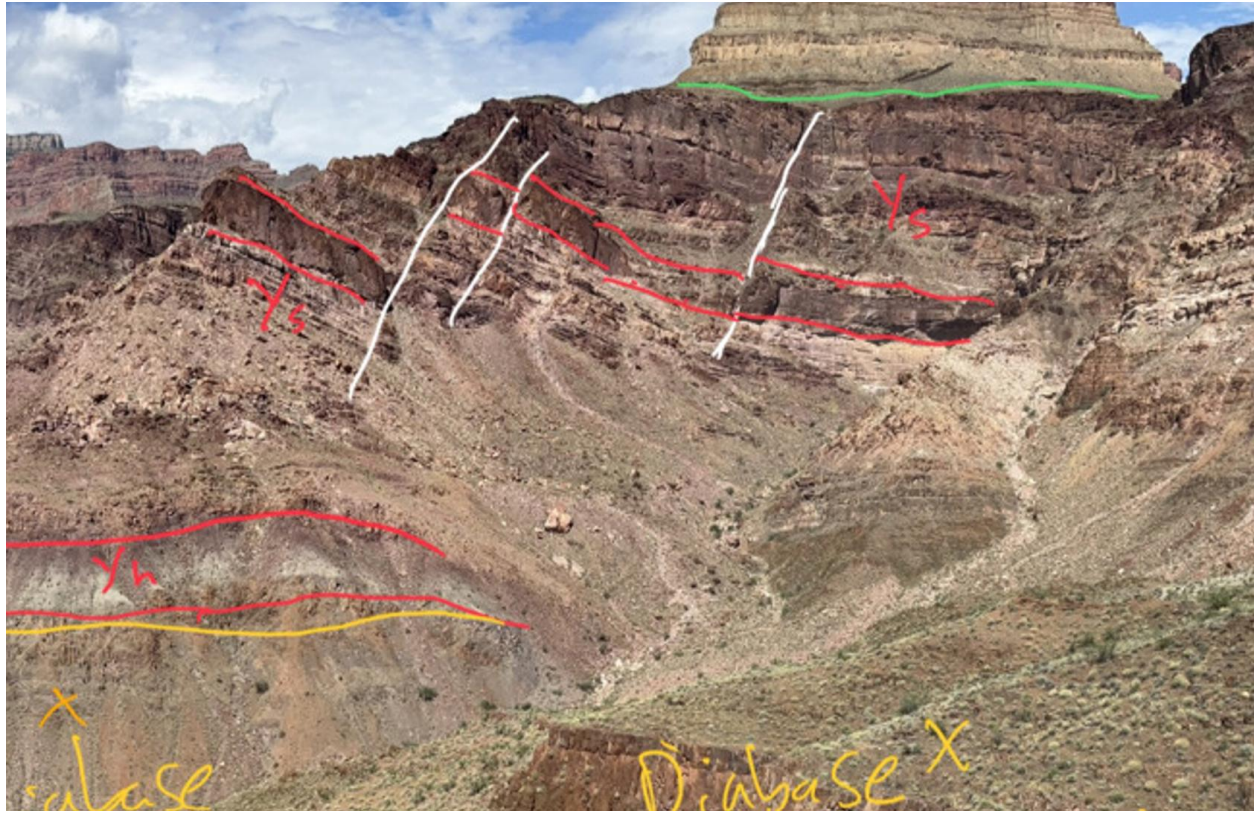
- **In a number of locations faults seem to be misplaced or missing**



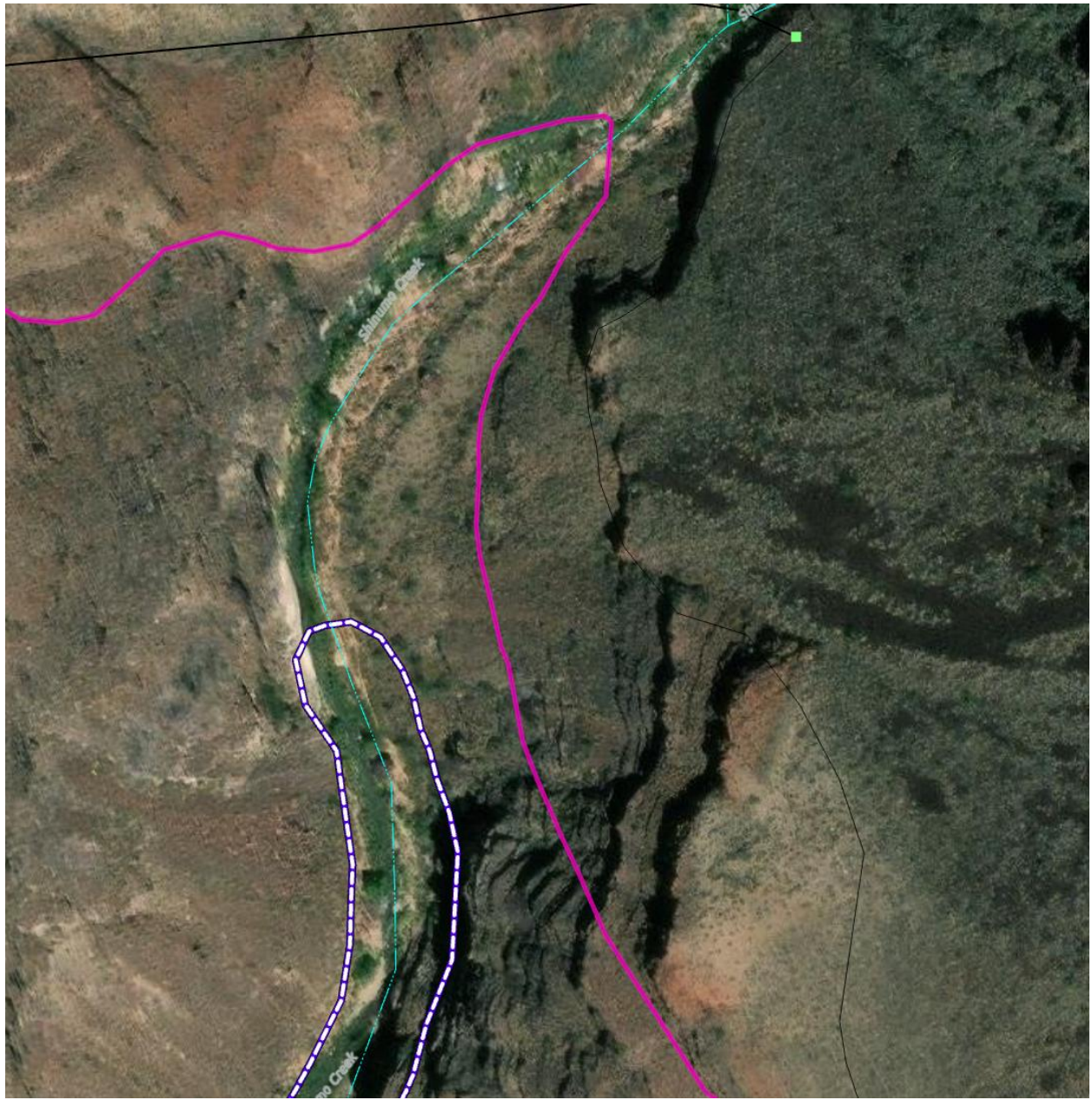
-This fault is offset from its trace by about 50m. No offset in the Bass at the X and fault

observed in the field at the star.

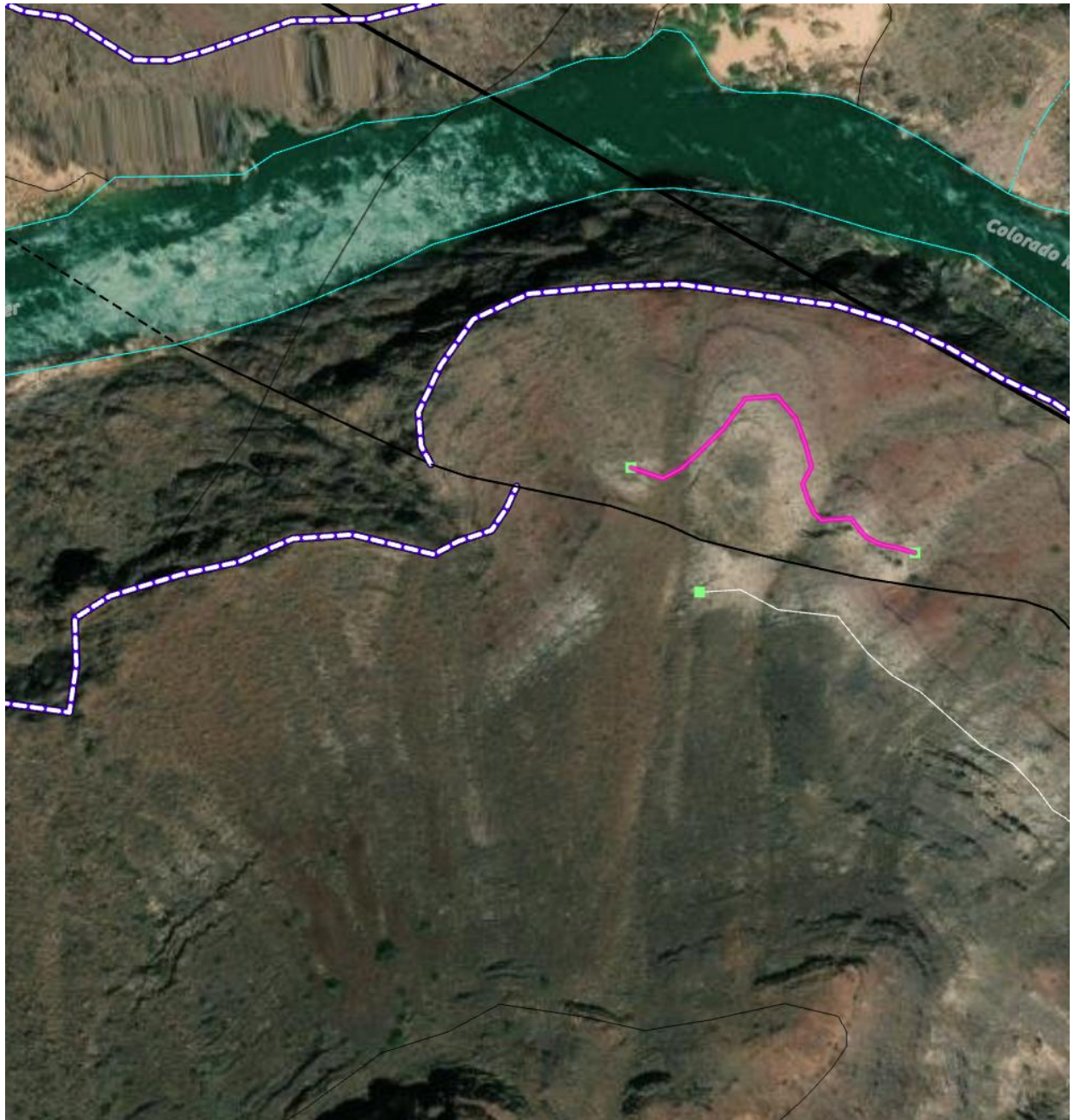




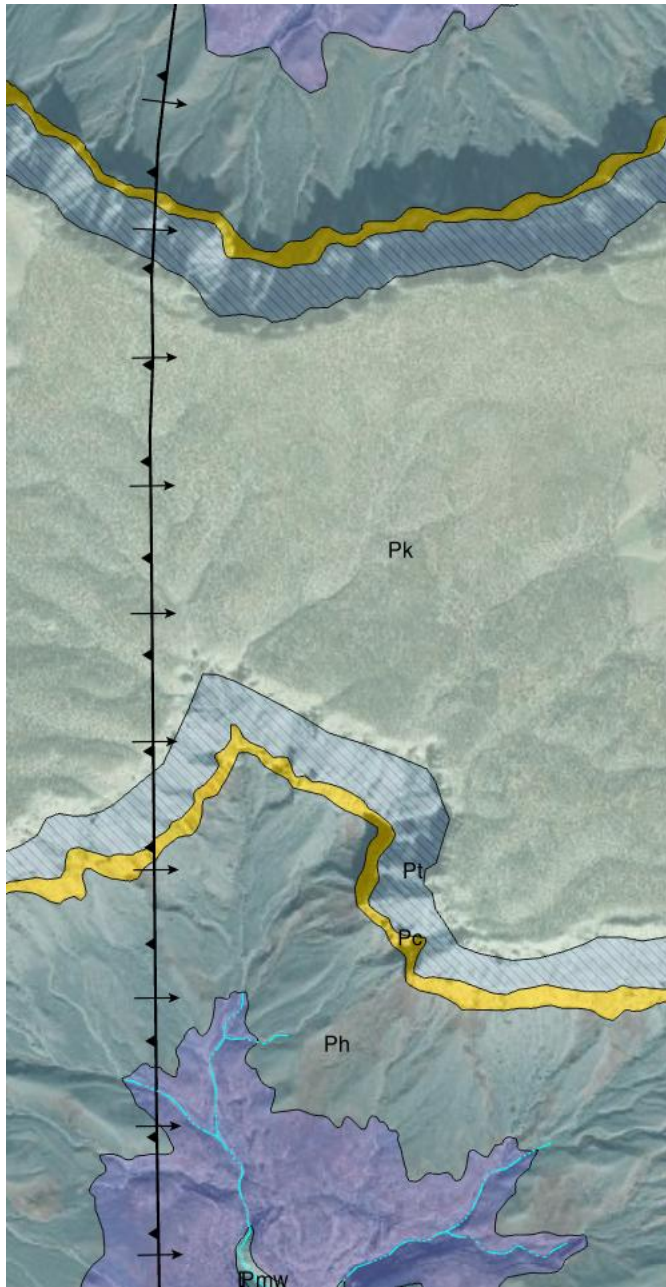
-Faults missing from this area (Hotauta Canyon)



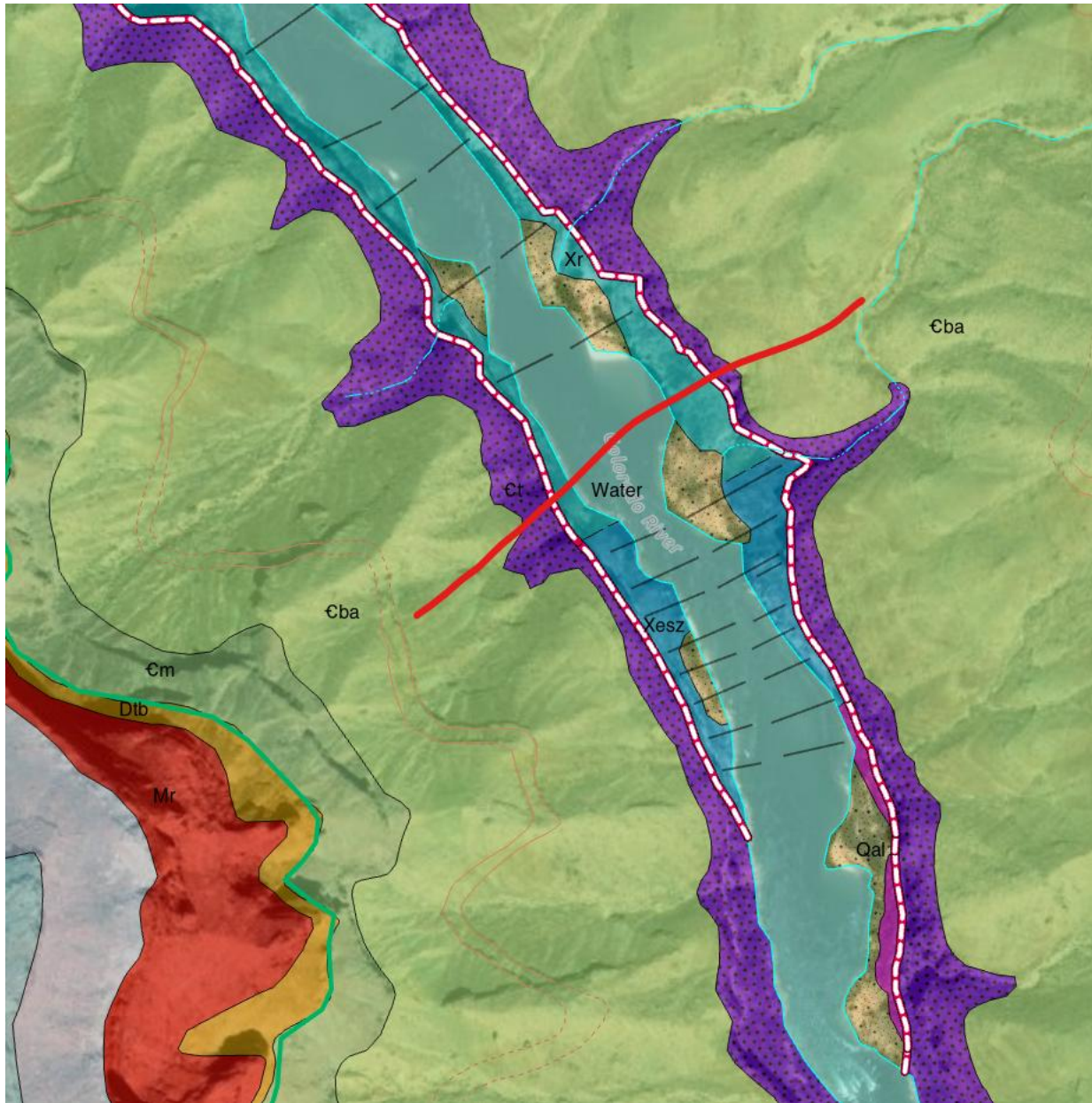
-Fault likely missing here too (Shinumo Creek)



-Fault separation exaggerated



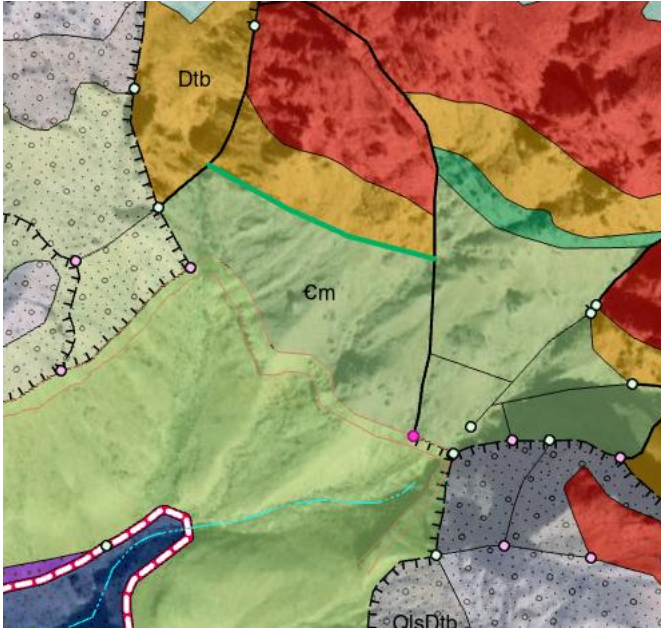
I see little evidence for a continuous (Butchart) fault through here though I have not been there on the ground. Not shown on previous maps though the monocline is and should be mapped there.



-Small brittle faults at the start of the Middle Gorge not shown but shown on previous maps and visible from the river. Travertine on the Tonto missing.

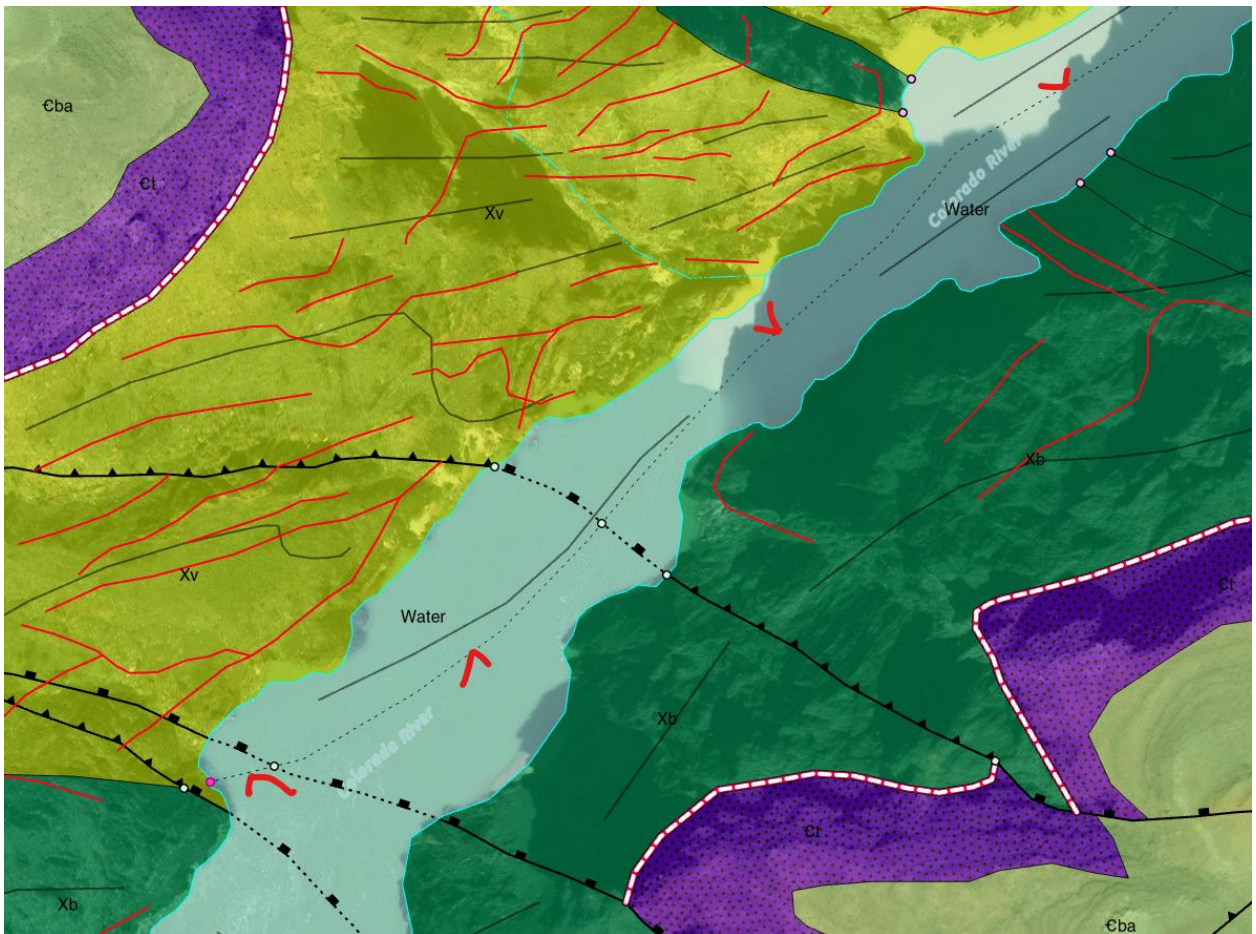
-I have not looked at the fault mapping systematically but noticed these and other locations where it could be improved. In other instances, I think the mapper have made some meaningful and defensible improvements to prior fault mapping.

- **Near Cogswell Butte Muav is shown directly over the Sanap Plateau**

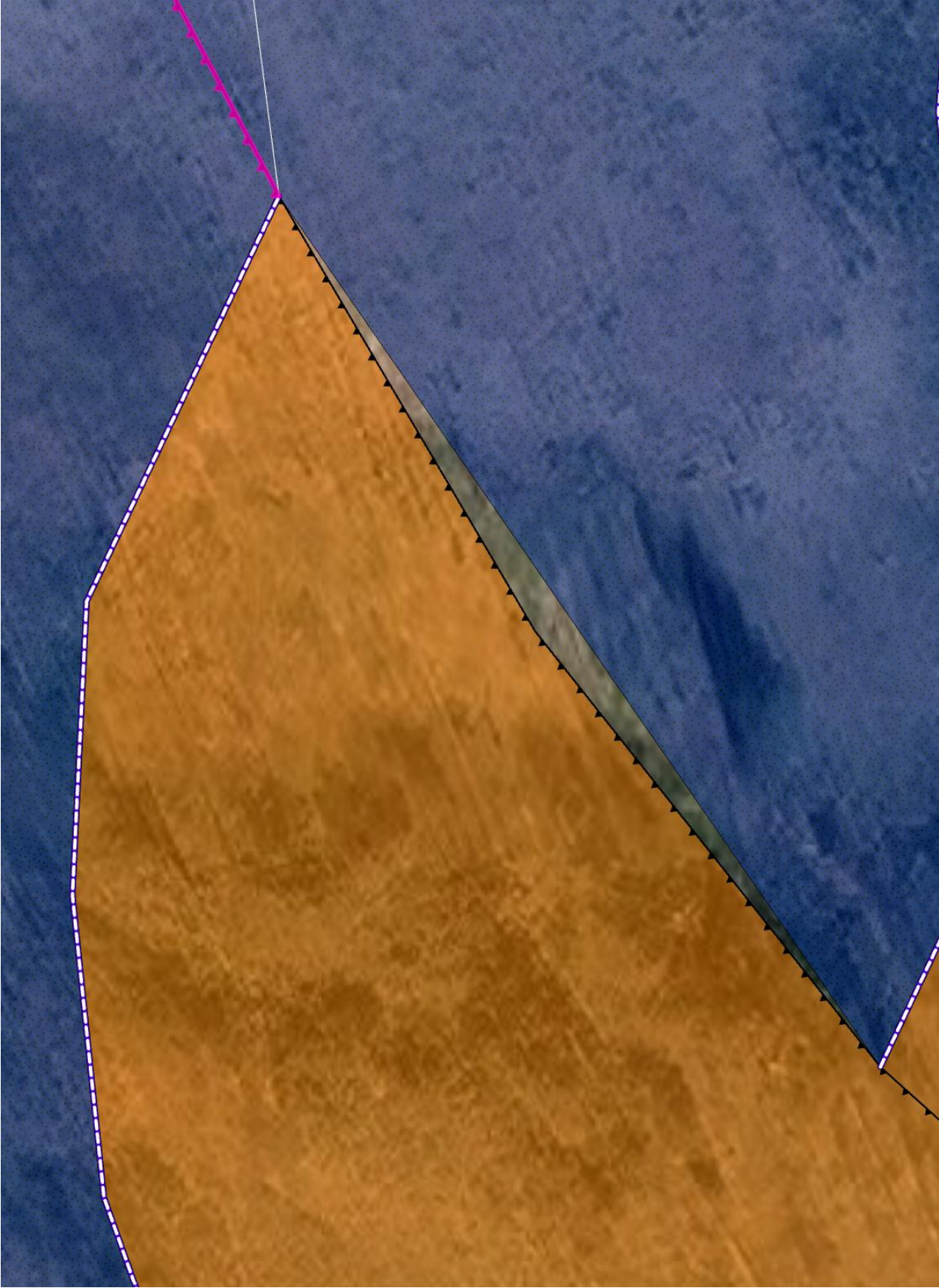


Also note the uncovered contacts between Muav that should be faults

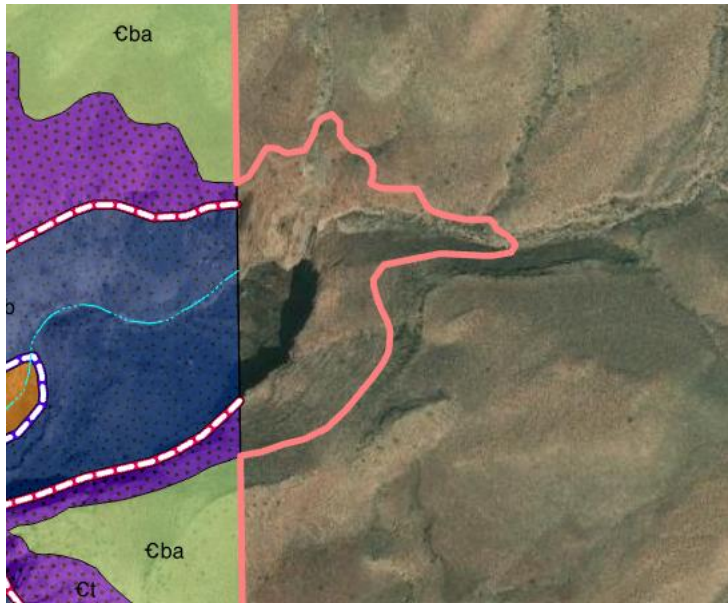
- **This concealed fault is shown as a contact**



- **Slivers are present in the mapunits polygons**

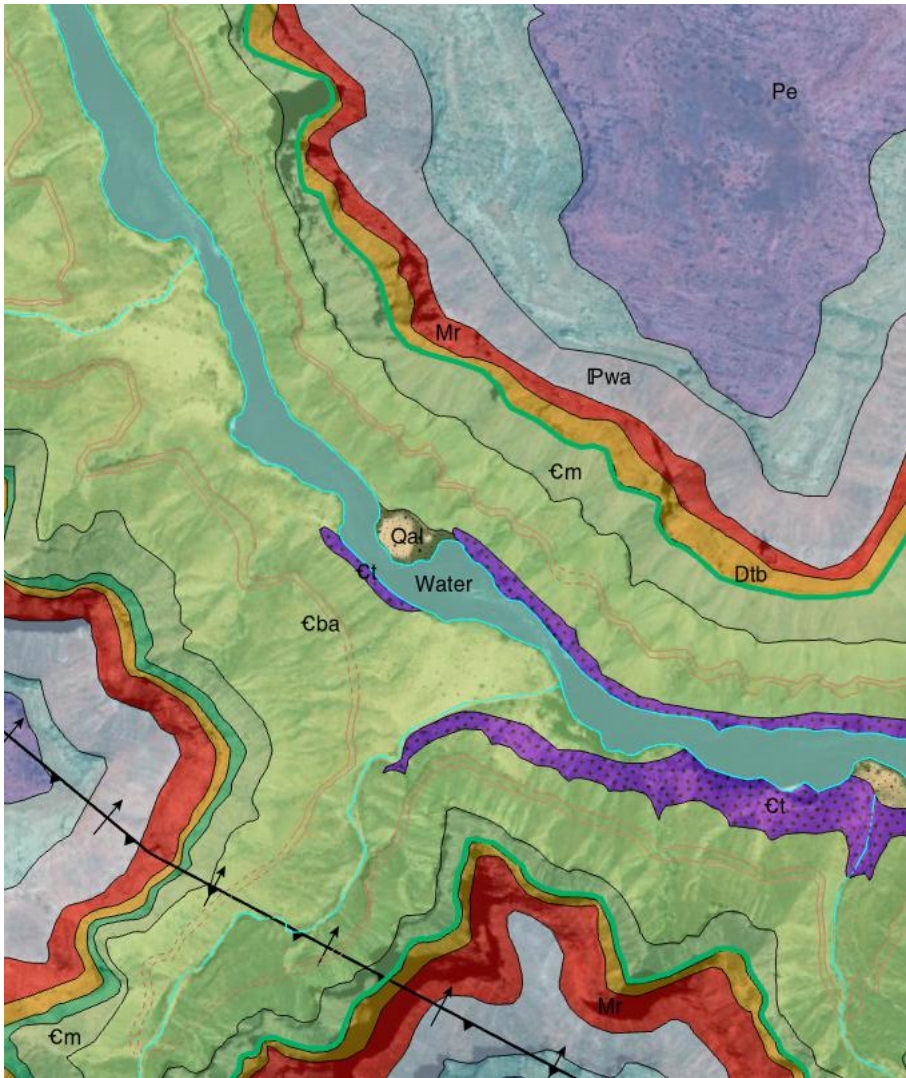


-This is on RL SW of the Wheeler Fold where there is an unlabeled polygon between a fault and a contact. Total of 25 such issues throughout the map.

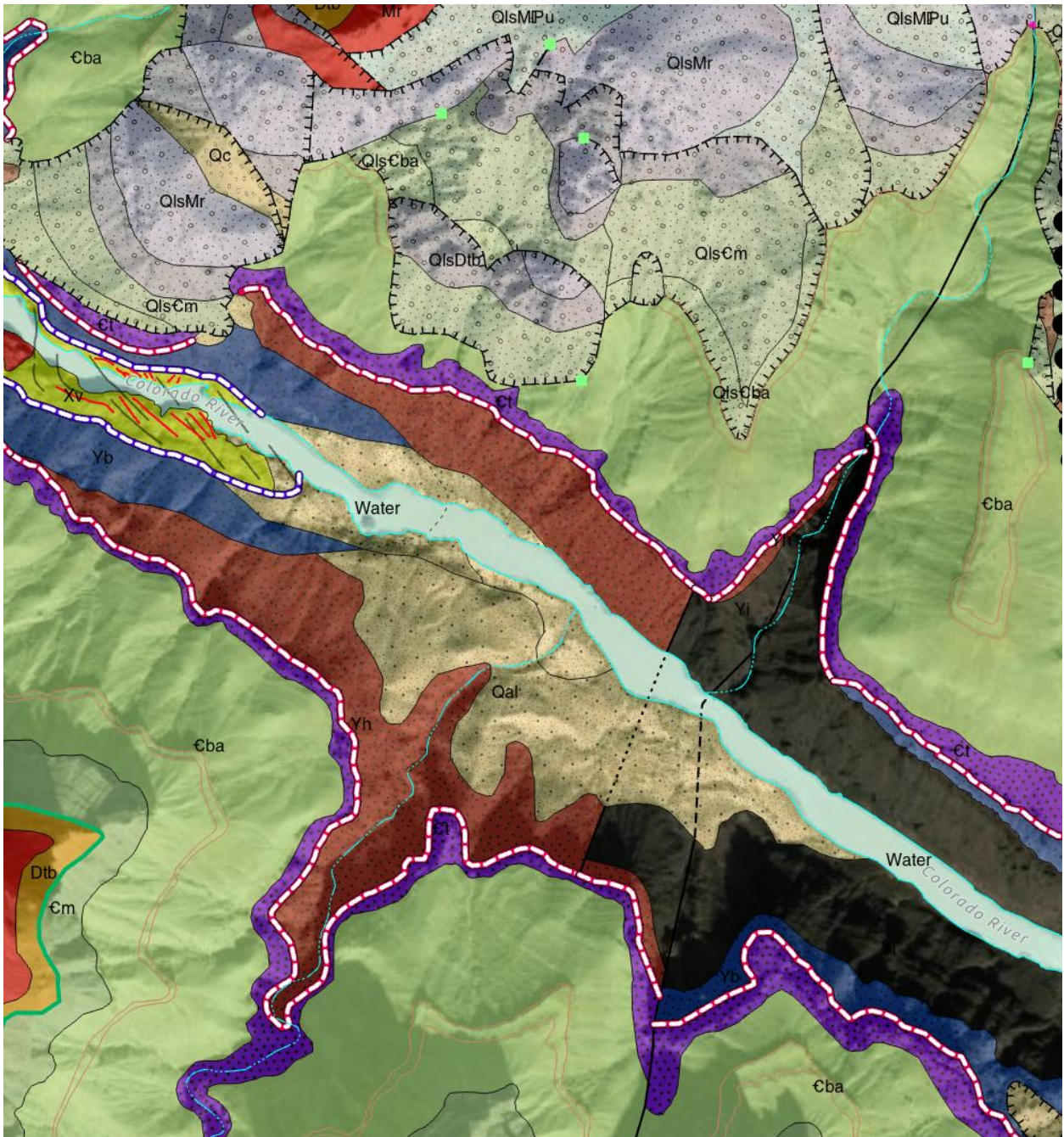


-This one is an example of an unlabeled polygon outside the map boundary

- **Missing surficial deposits – although I understand that you are not mapping some surficial deposits such as talus cones other surficial features are incompletely shown such as travertine and Colorado River gravels**



-Debris maps inconsistently mapped – large fans at Forrester and the next side canyon on the left missing. Well exposed river gravels missing from the map here too as well as in a number of other locations.



-Missing the lake deposits behind Owls Eyes. Also note that the great unconformity is misplaced at the start of the basement exposures.

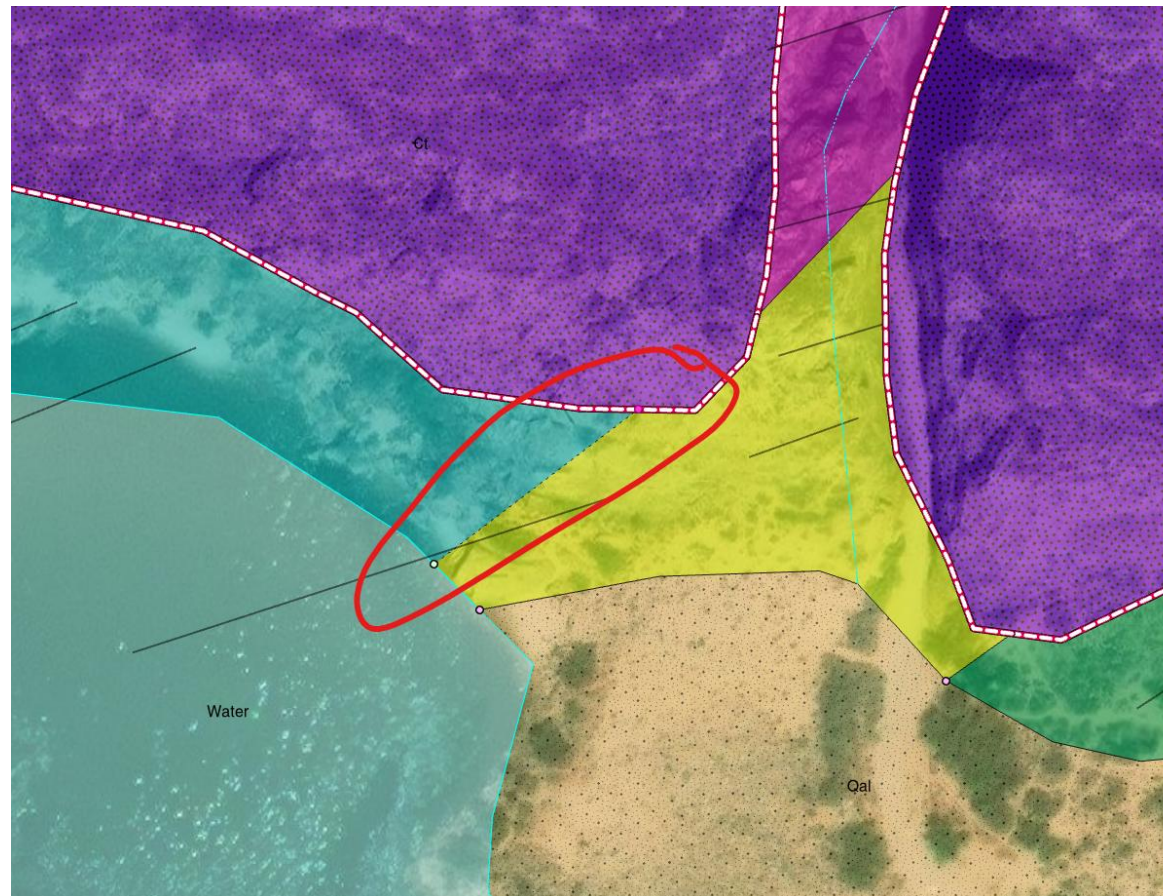
-I have not looked at all the surficial mapping throughout the map area; more missing features certainly exist.

- **Automated tools to check for logical inconsistencies do not work on this database because it is not fully GeMS compliant. I have not looked at GeMS compliance in detail but here are GeMS issues that stop the tool from working; I would guess that this database is not even level 1 GeMS compliant:**

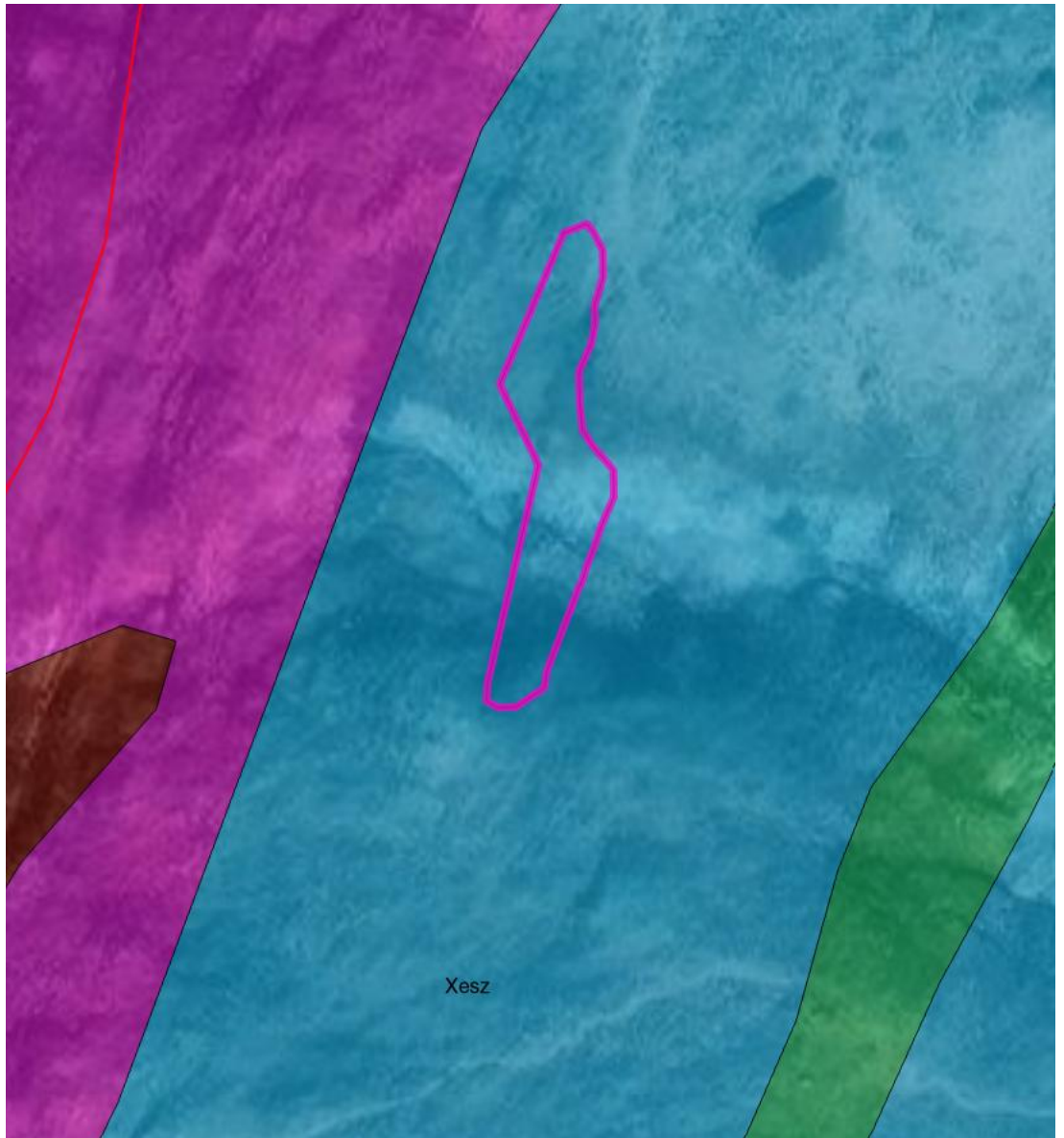
- FieldNames, which are actually lowercase even though the alias in CamelCase
- Mapunits are inconsistent between the polygons and the DMU table
- Some mapunits are missing from the DMU table (e.g. QlsCba) and Plate 1
- Some polygons had no mapunit (see above)

-Getting the tools running (GeMS Topology Check) is important because it allows you to find not just topology errors but logical inconsistencies that would otherwise be very time consuming to find. After a fair amount of tweaking, I was able to get the database close enough to GeMS compliance to run the tool and found:

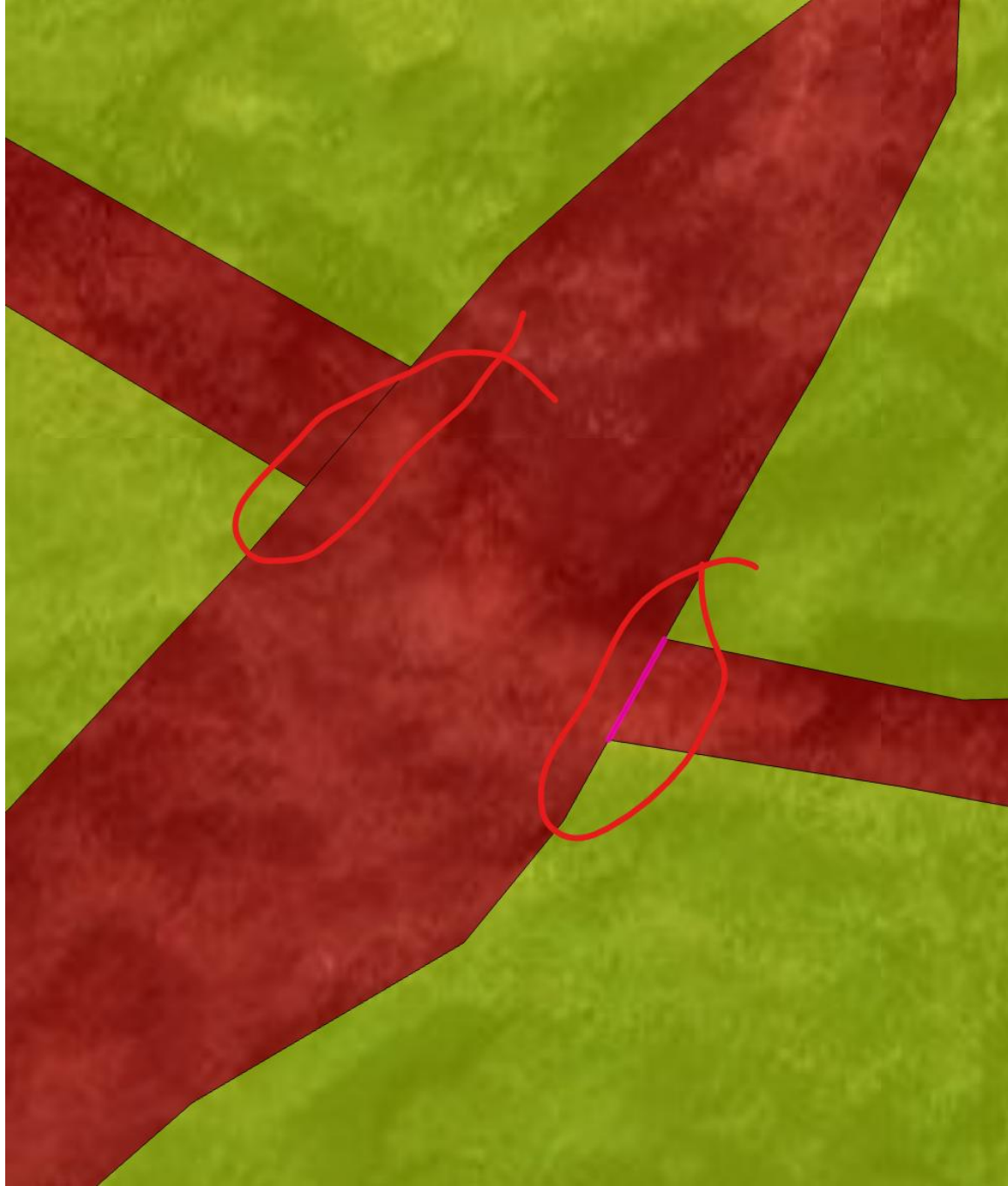
- There are 4 concealed contacts that separate different units, which should not happen



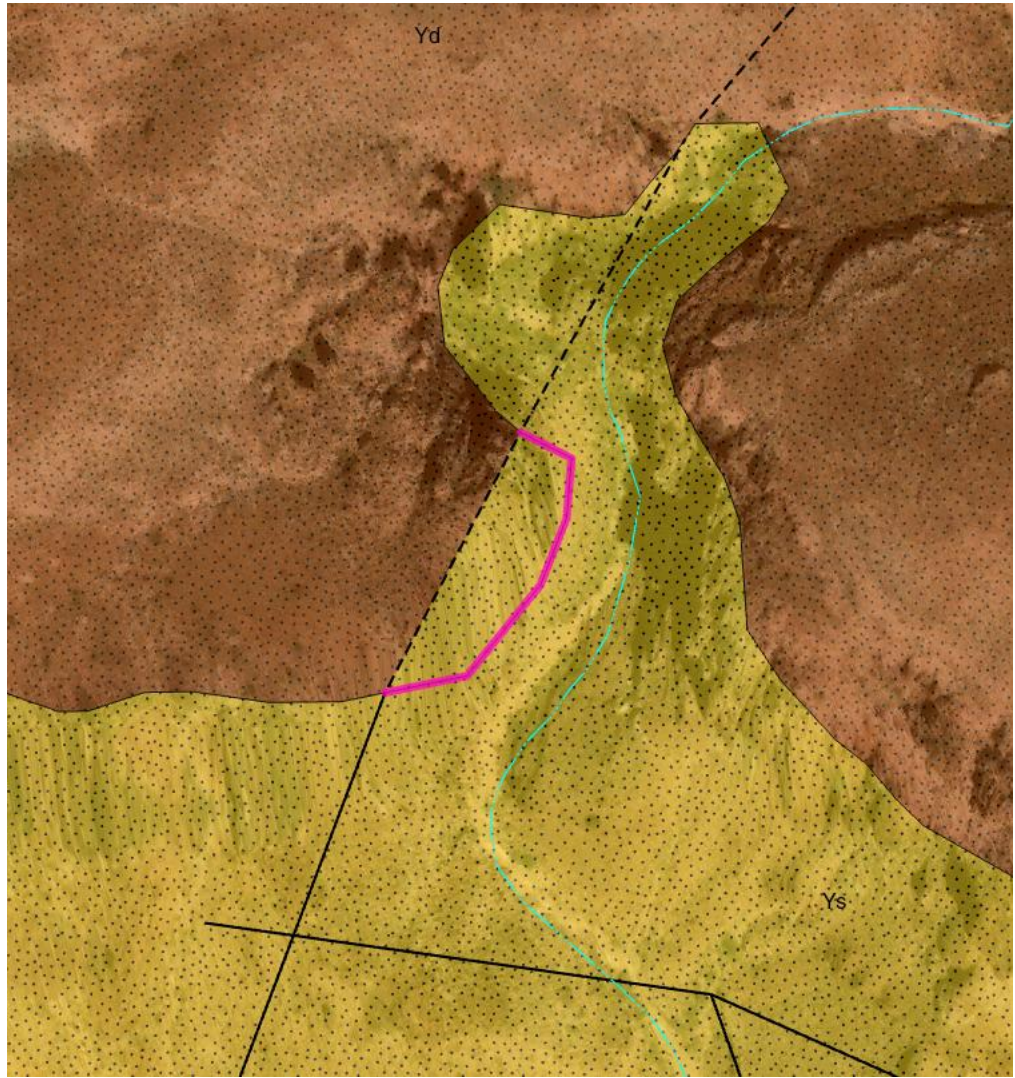
- There are many unconcealed contacts that separate the same unit, which should also not happen. Some of these are related to how beds were mapped within the Bass (ideally you should give the ash bed its own map unit or map the contracts as MapUnitLines), but others are clear errors.



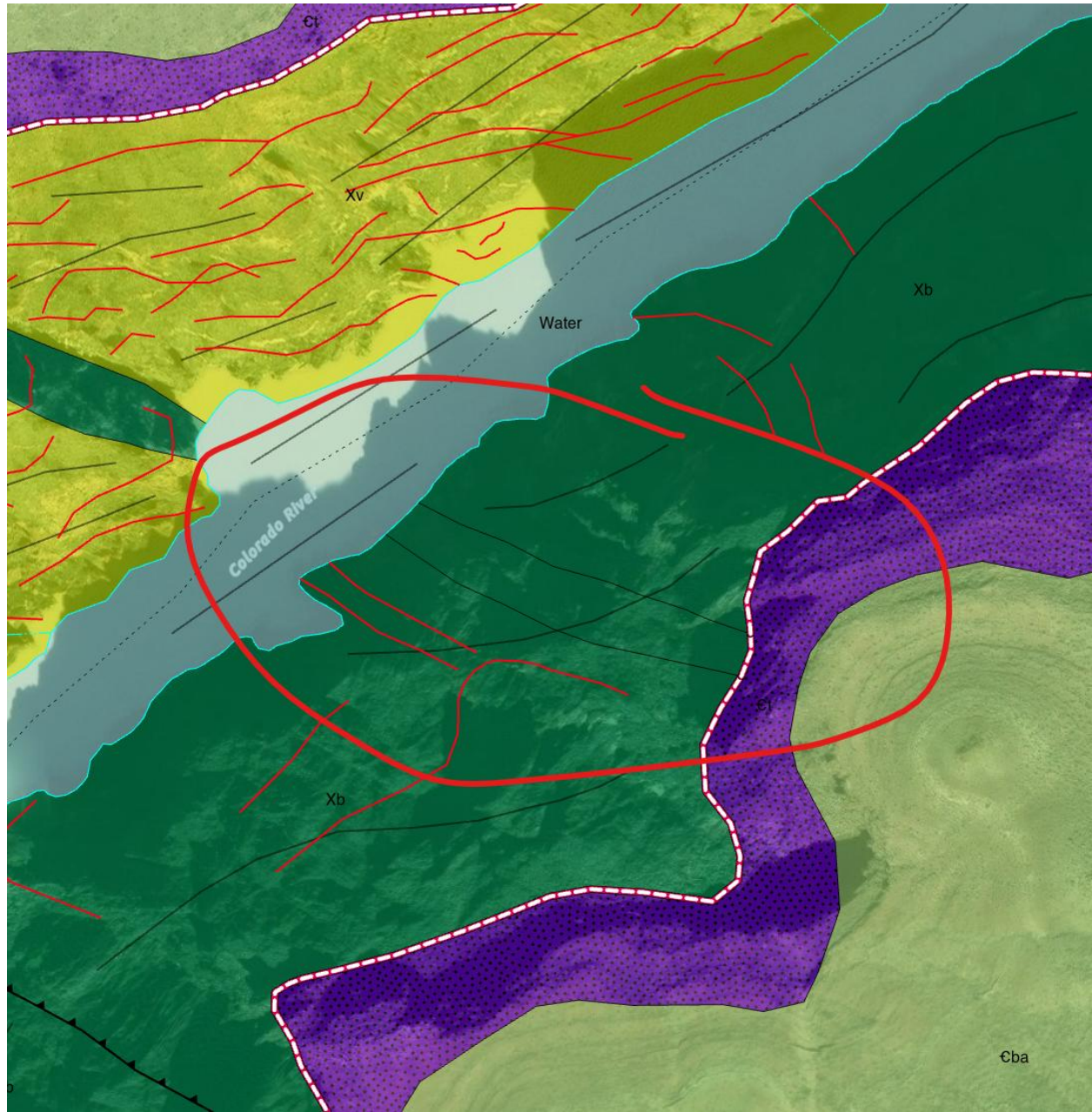
Blob of Xesz in Xesv



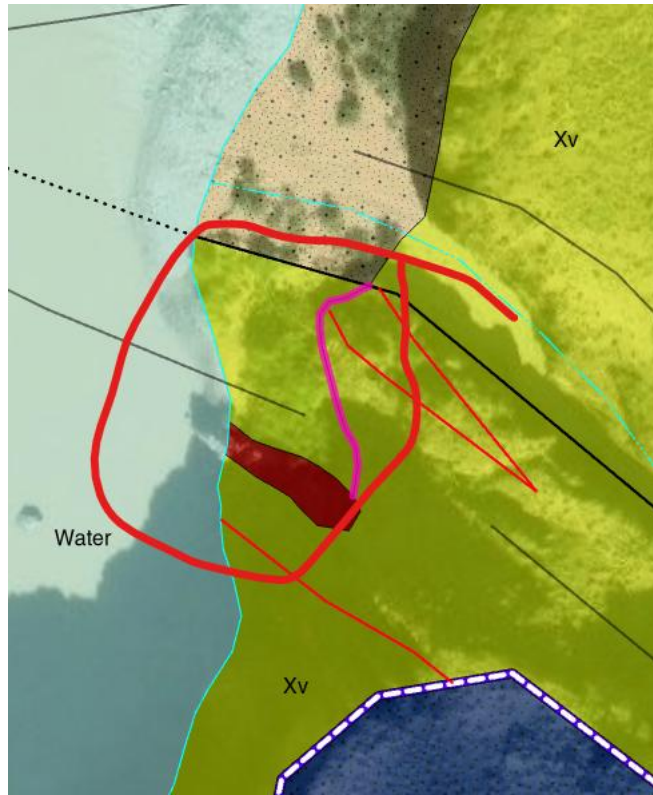
Merge Xg polygons



Polygon should be Yd



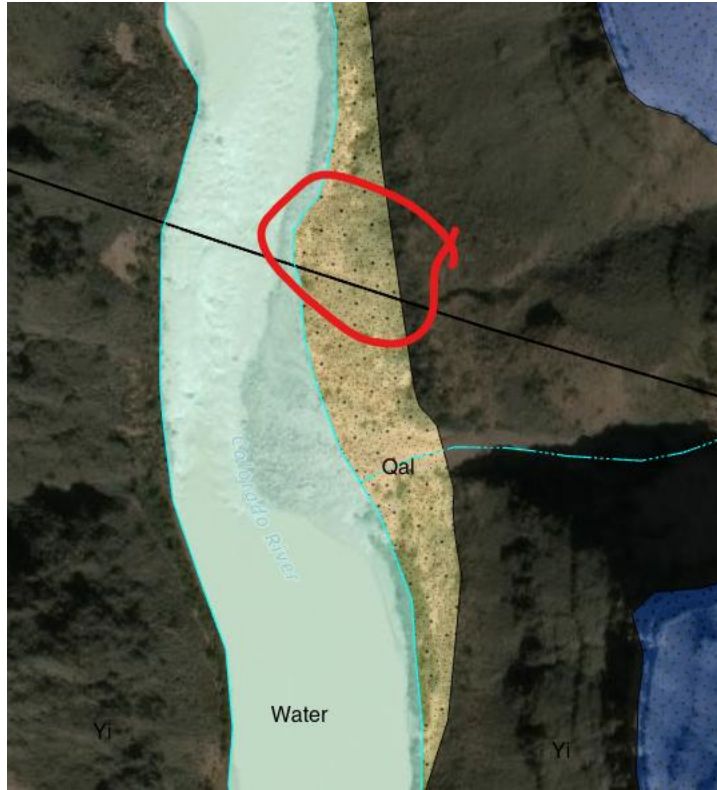
Should be Xbr in Xv?, obviously not Xbr in Xbr



Should be Qal up against Xgr?

-Many more of these...

- There are a number of unconcealed faults that offset young units including water, Qal, Qc, and Qls. These imply Quaternary faults where there are none.



In summary I think there are many logical inconsistencies with this map that need to be fixed before it's published. This is not to say that the mapping is not a major

contribution – it just needs a lot of clean up to show off that contribution and not have the omissions and errors detract.