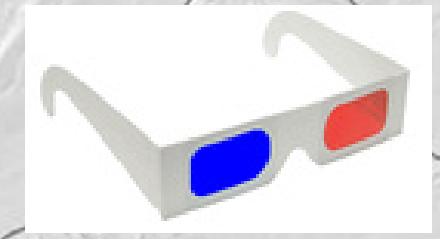
Regional Geologic Remote Sensing, Ruhuhu Basin, Tanzania

(a virtually unexplored rift basin)

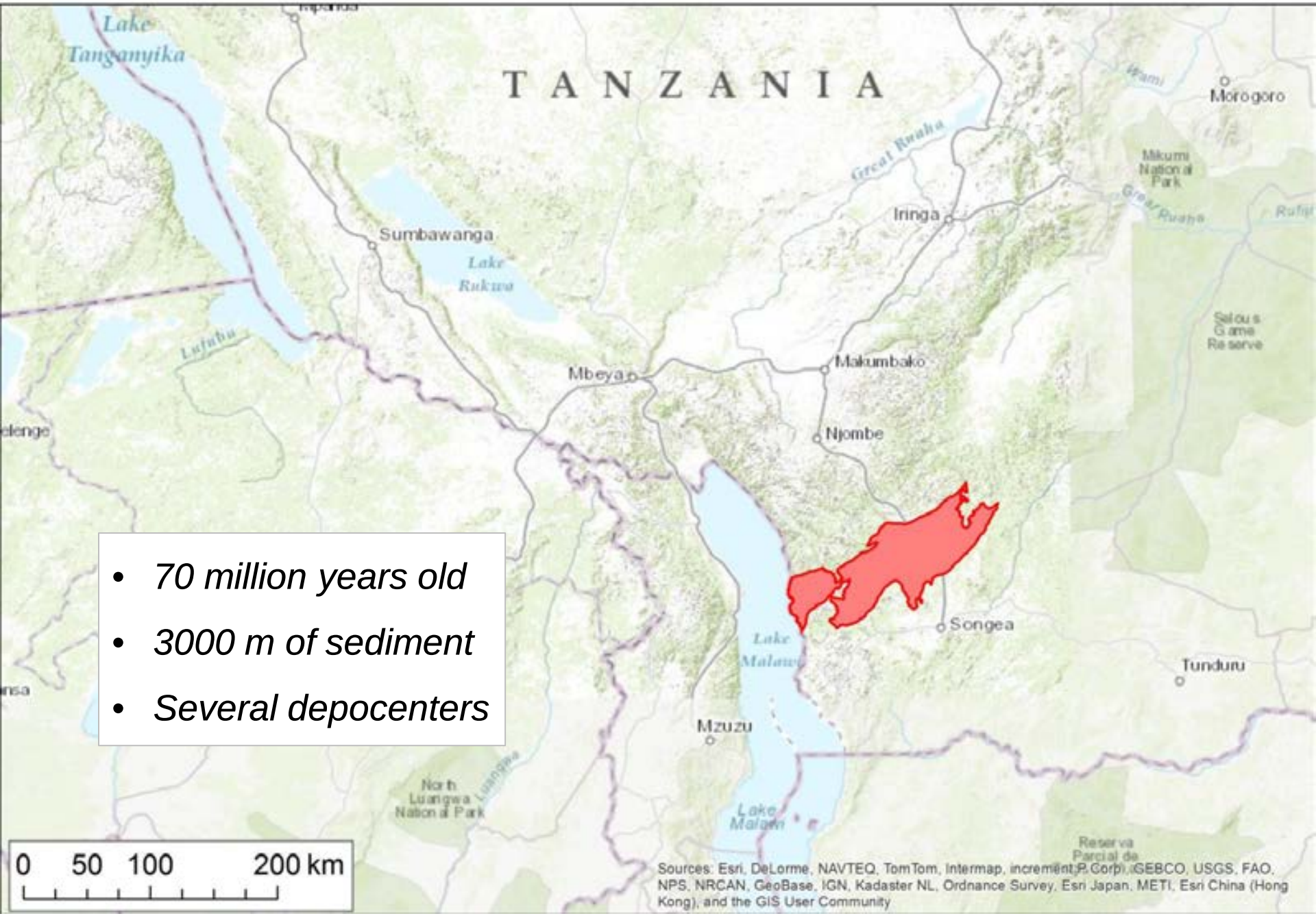
James Ellis, Ellis GeoSpatial, USA

Justyn Wood, Australia



GRSG Oil & Gas Remote Sensing Workshop 2018, Boulder, CO, 11-12 July 2018

Ruhuhu Basin, Tanzania



- *70 million years old*
- *3000 m of sediment*
- *Several depocenters*

Why was Remote Sensing Used?

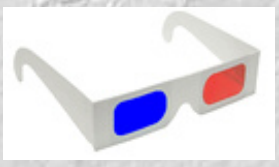
1) improve understanding of geology,
2) find some new exploration leads,
3) support seismic planning,
4) build a regional GIS database that enables integration of other surface & subsurface data.

Data

1) Landsat 5 & 8
2) SRTM DEM

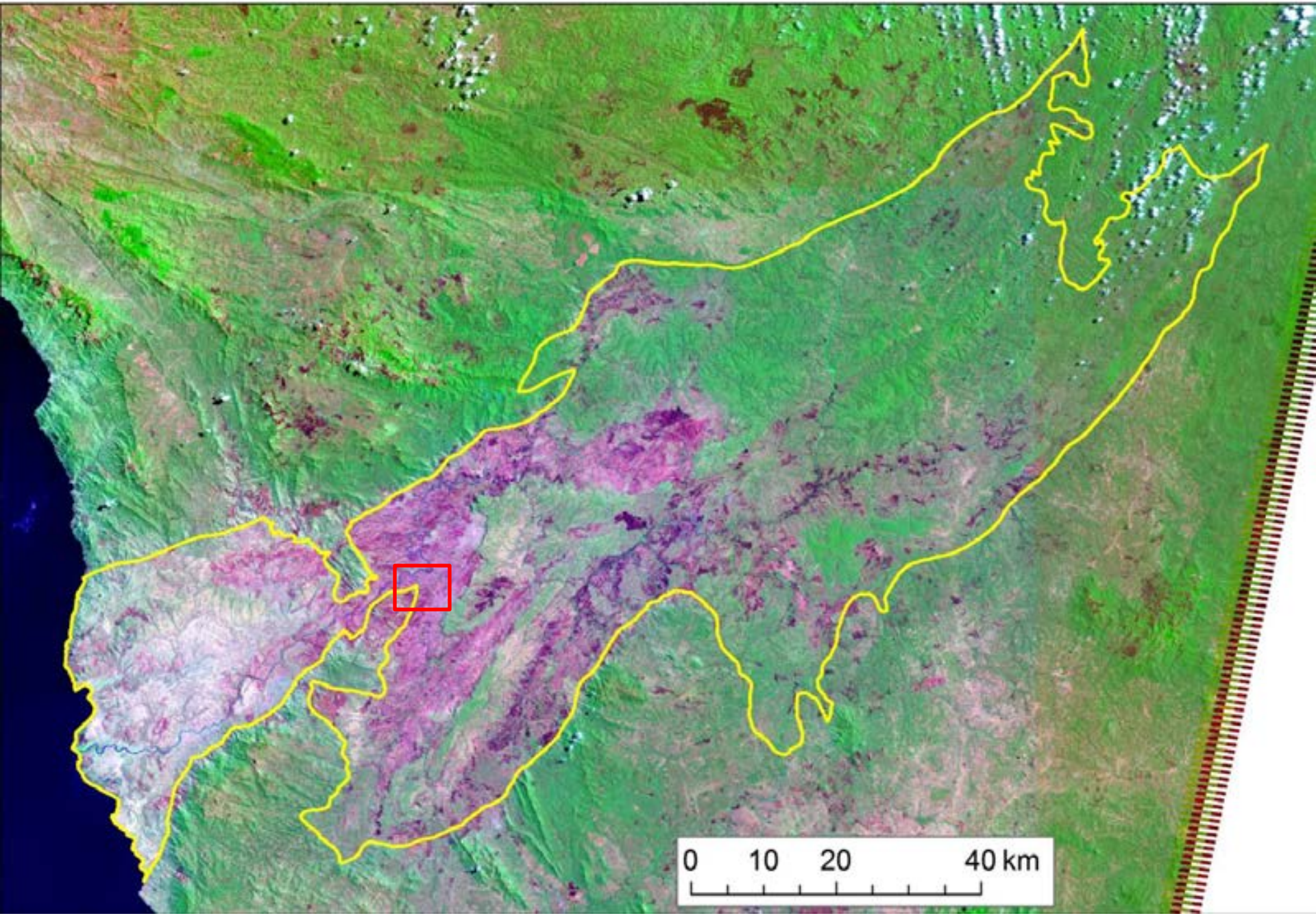
Synthetic Stereo DEMs

3) ASTER Color IR
4) ASTER overlapping stereo bands

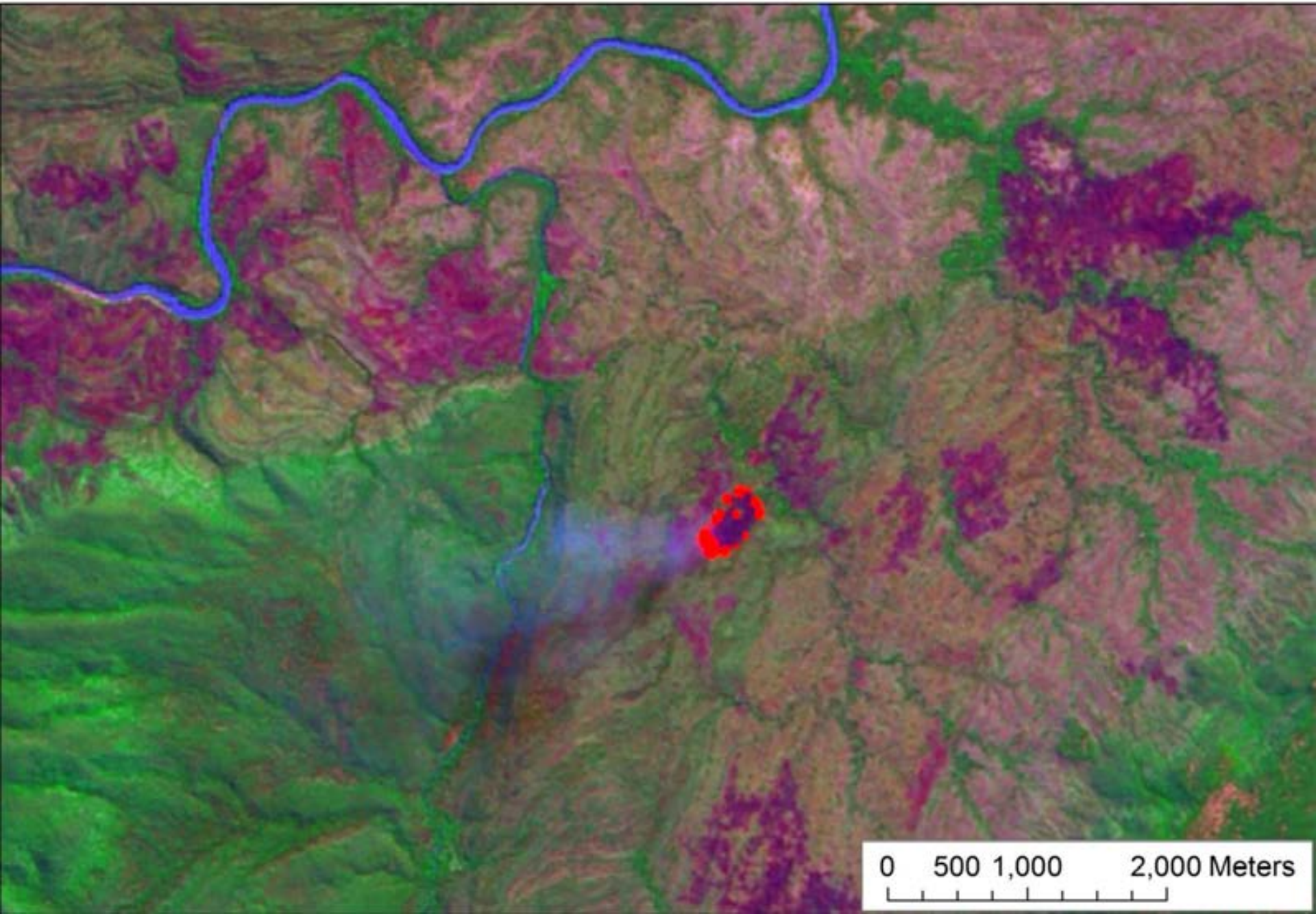


5) ASTER Thermal IR

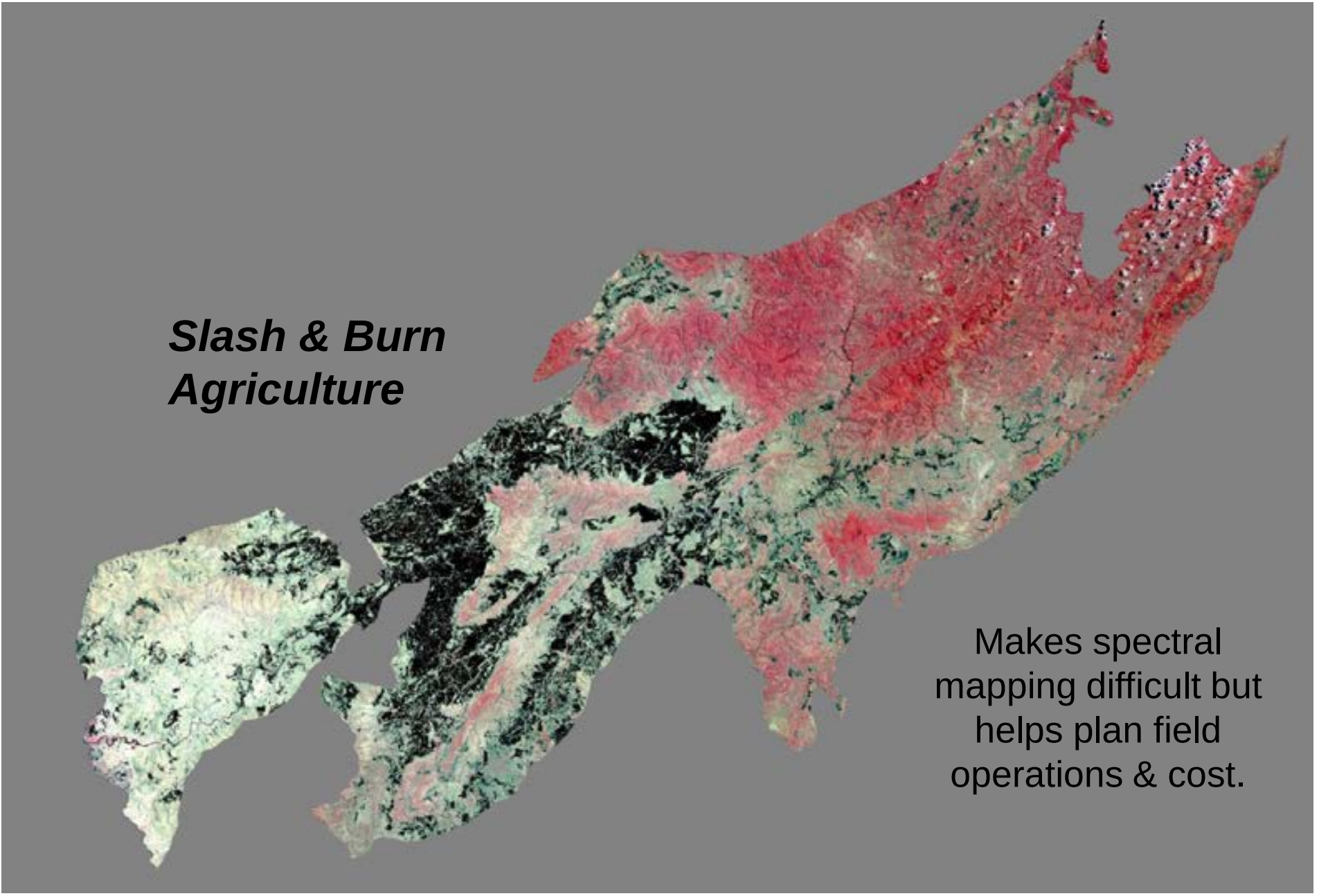
Landsat TM Sep 2005 30 m 742 as RGB



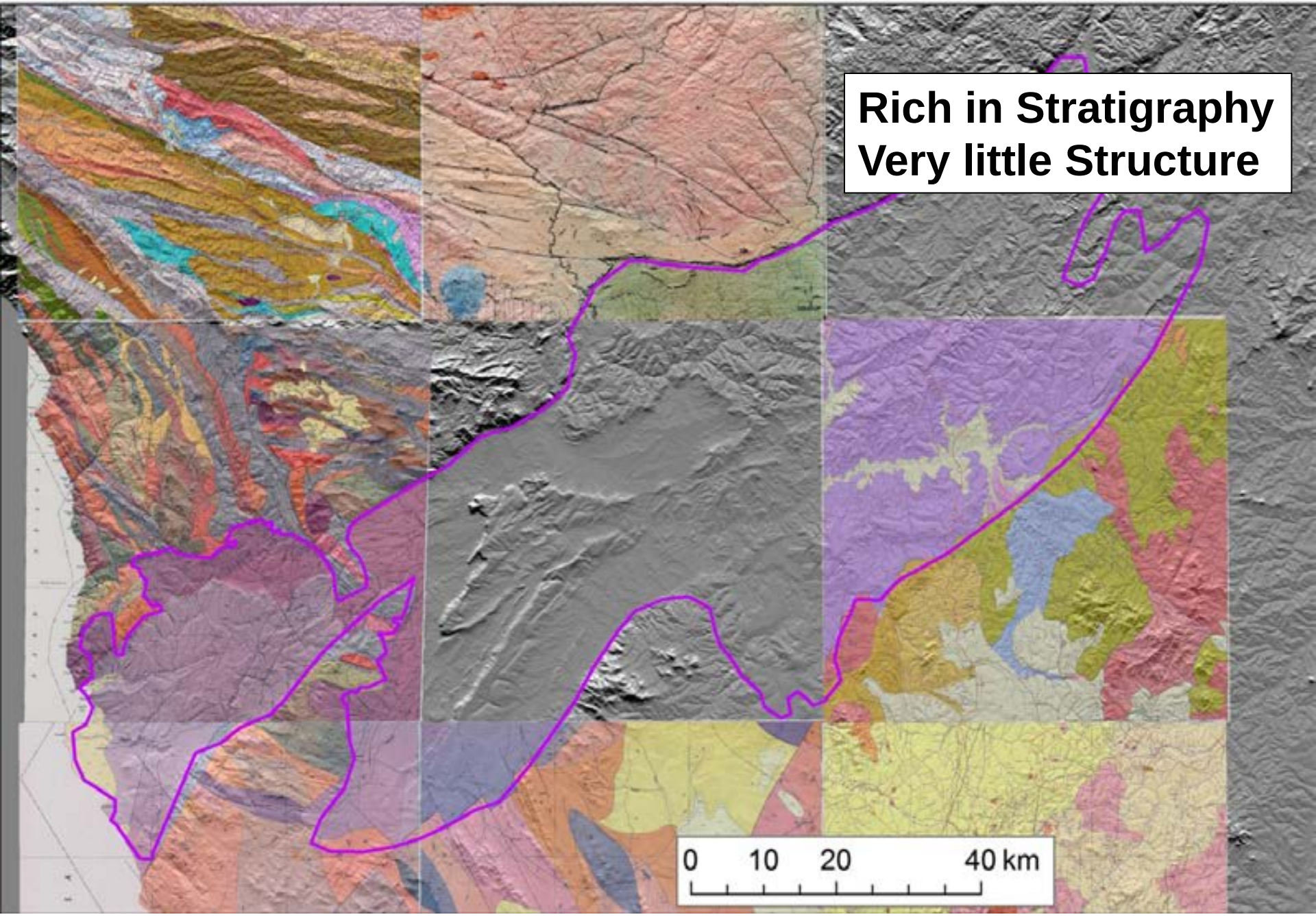
Landsat 8 Enhanced Color (753 as RGB) Purple = Burn Scars



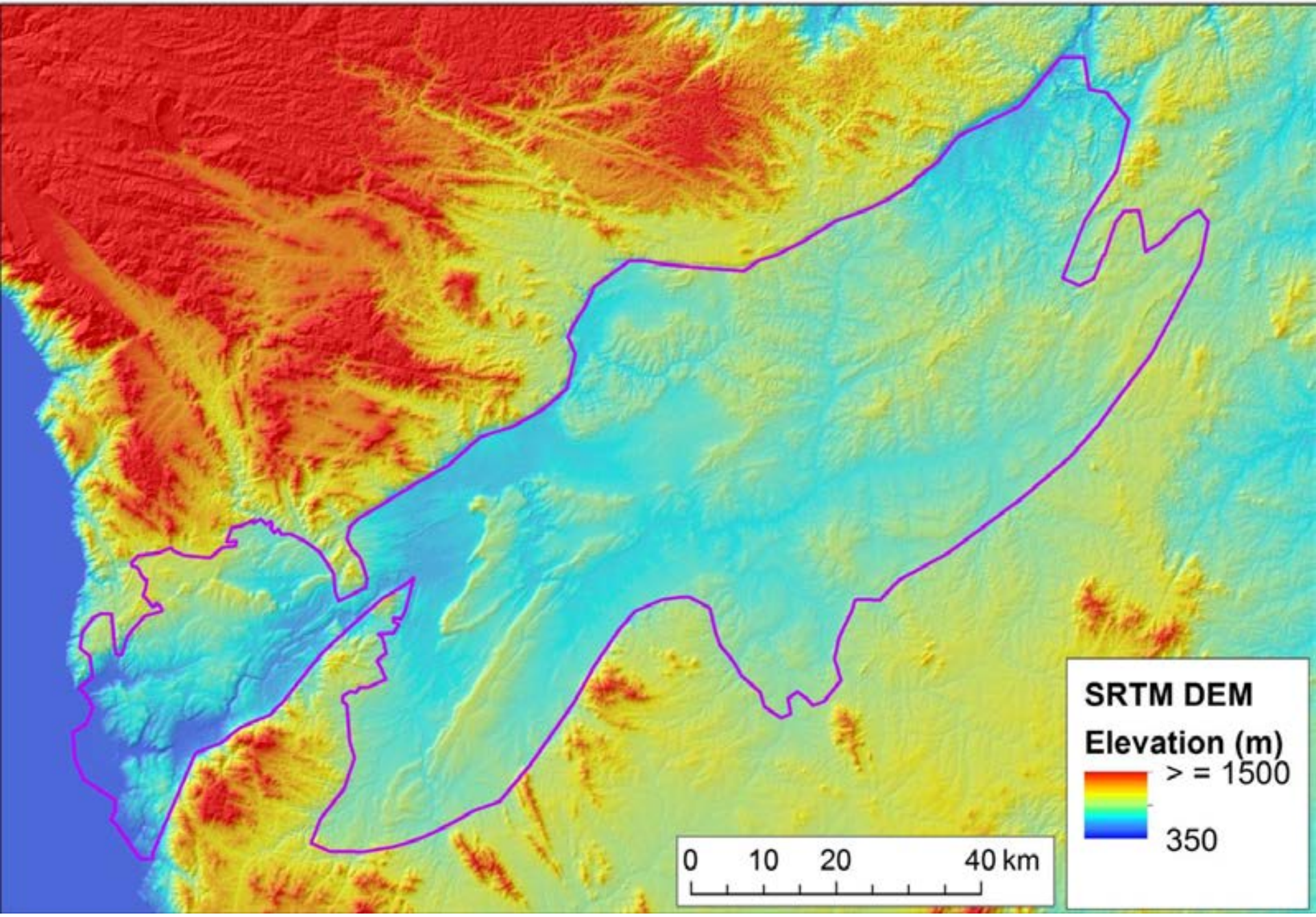
Burn Areas (black) with CIR image (vegetation shades of red)



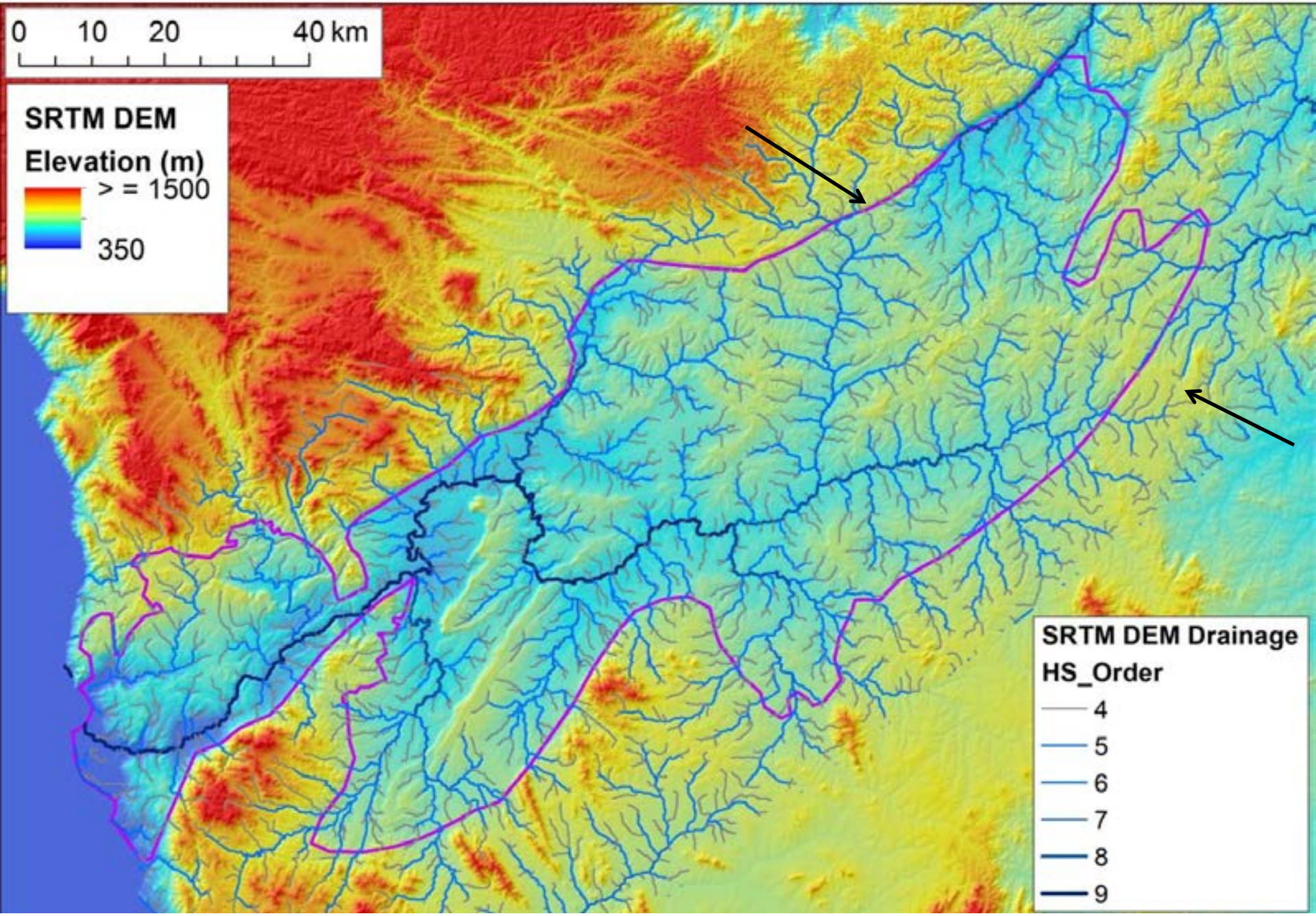
1950-1960 1:100,000 Geologic Maps, Ministry of Energy & Minerals



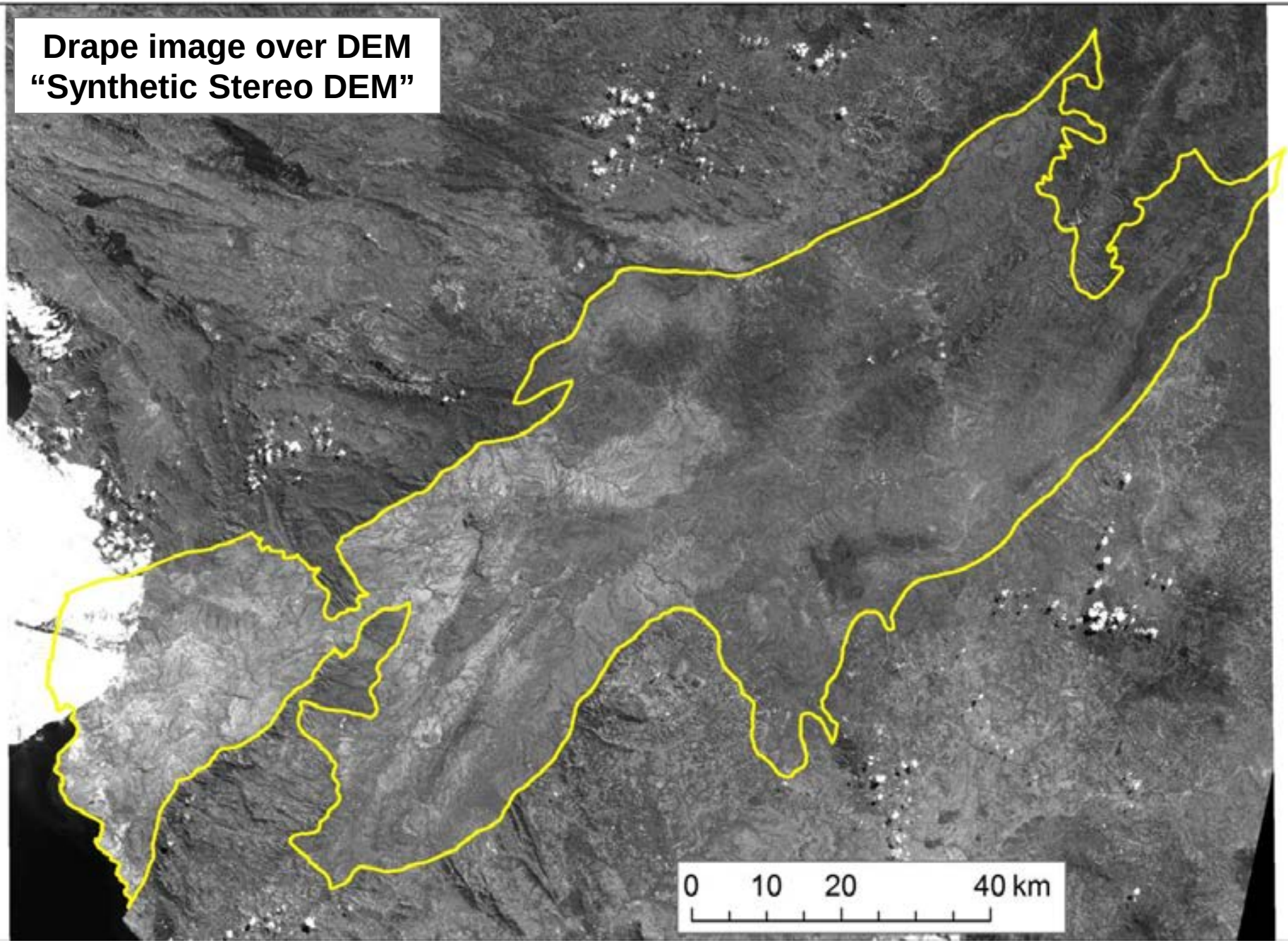
Ruhuhu Basin Outline Displayed on the SRTM DEM



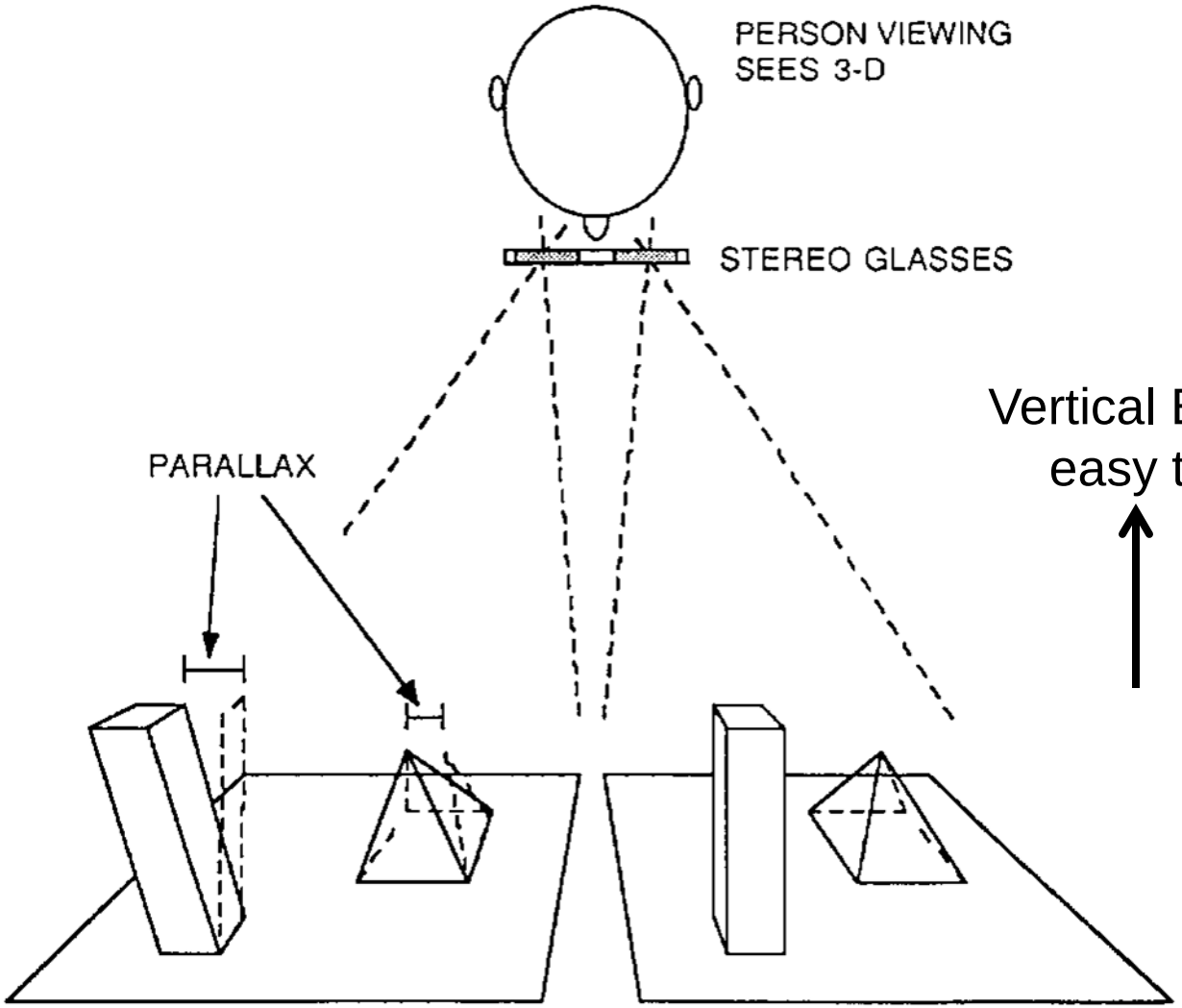
Drainage Patterns in the Ruhuhu Basin, Tanzania



Landsat8 OLI July 2014 15 m Panchromatic



Creating a Synthetic Stereo DEM

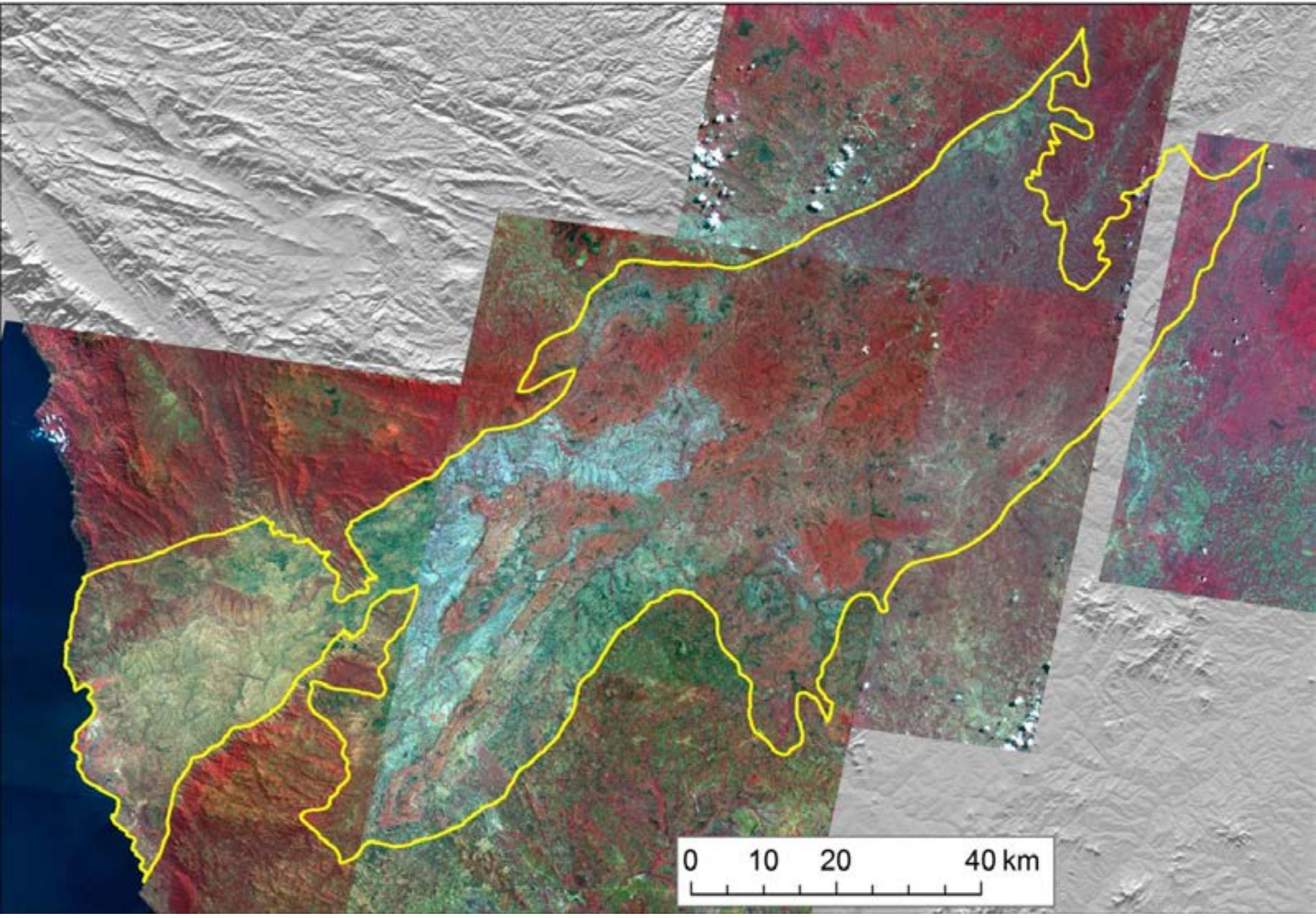


Vertical Exaggeration
easy to change.

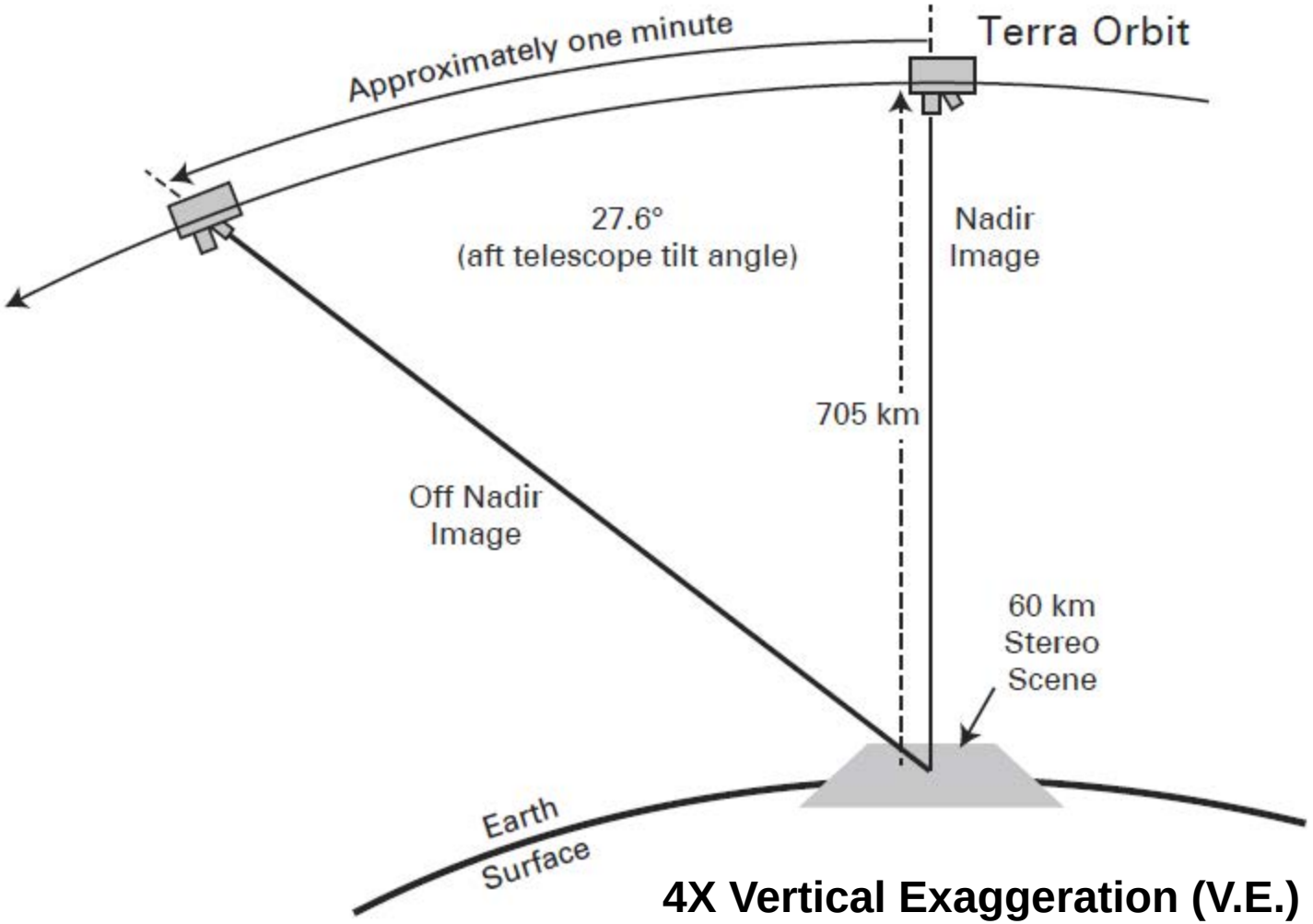
Red/Cyan Anaglyph 15m Landsat8 pan over SRTM DEM 8X VE

Synthetic Stereo DEM

ASTER CIR 15 m 2012-2013 imagery

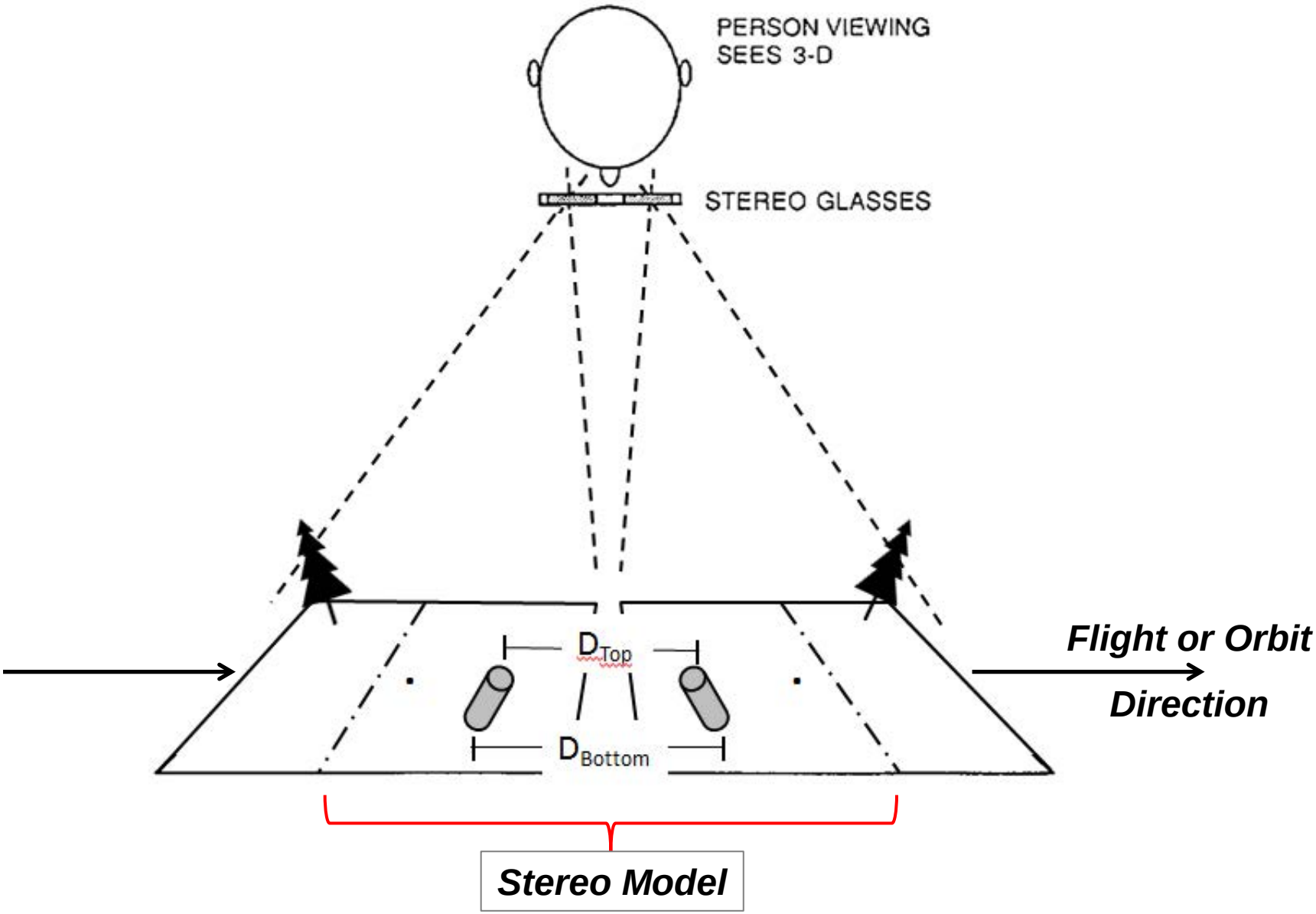


Overlapping ASTER NIR grayscale images enable stereoscopic viewing

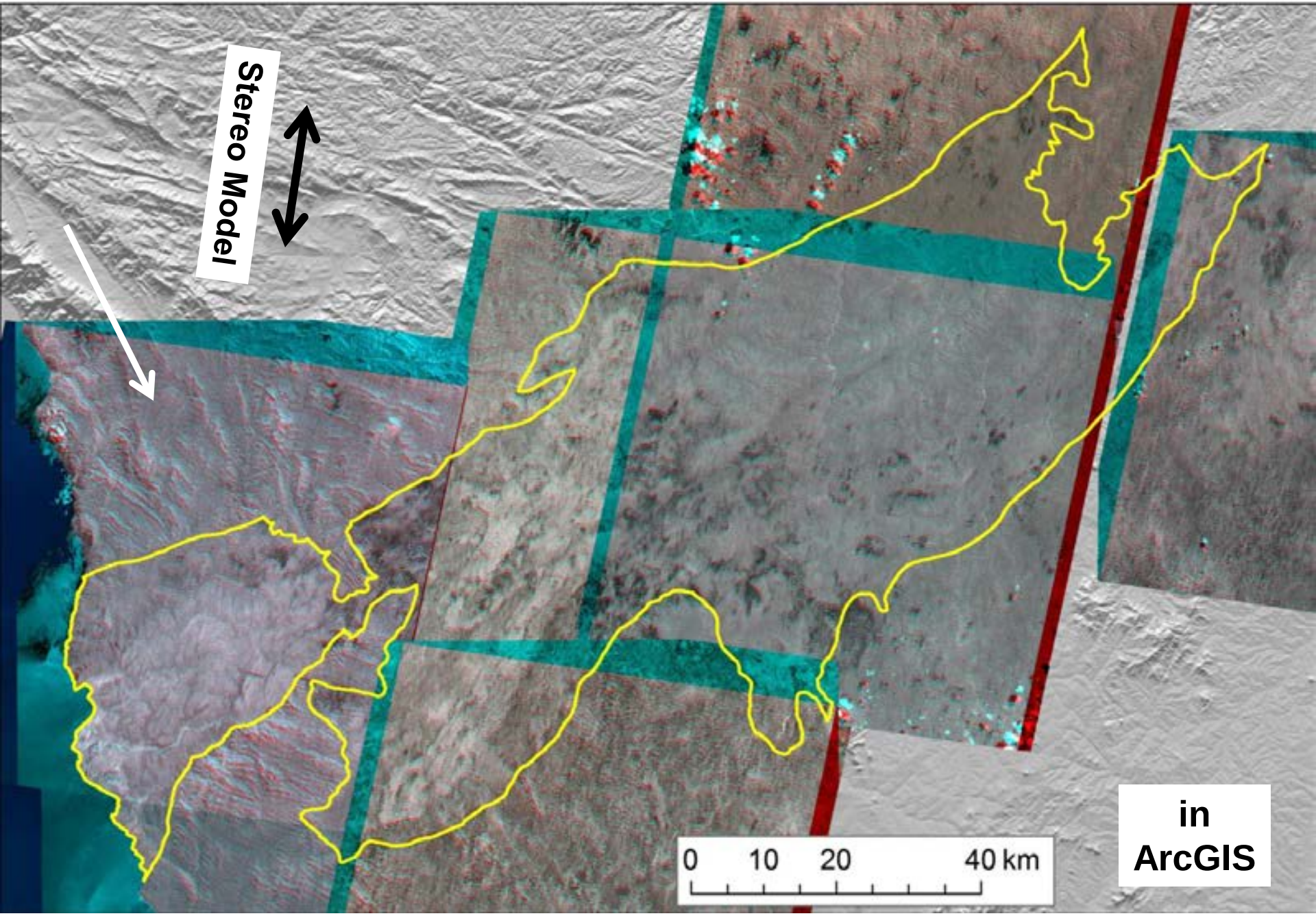


4X Vertical Exaggeration (V.E.)

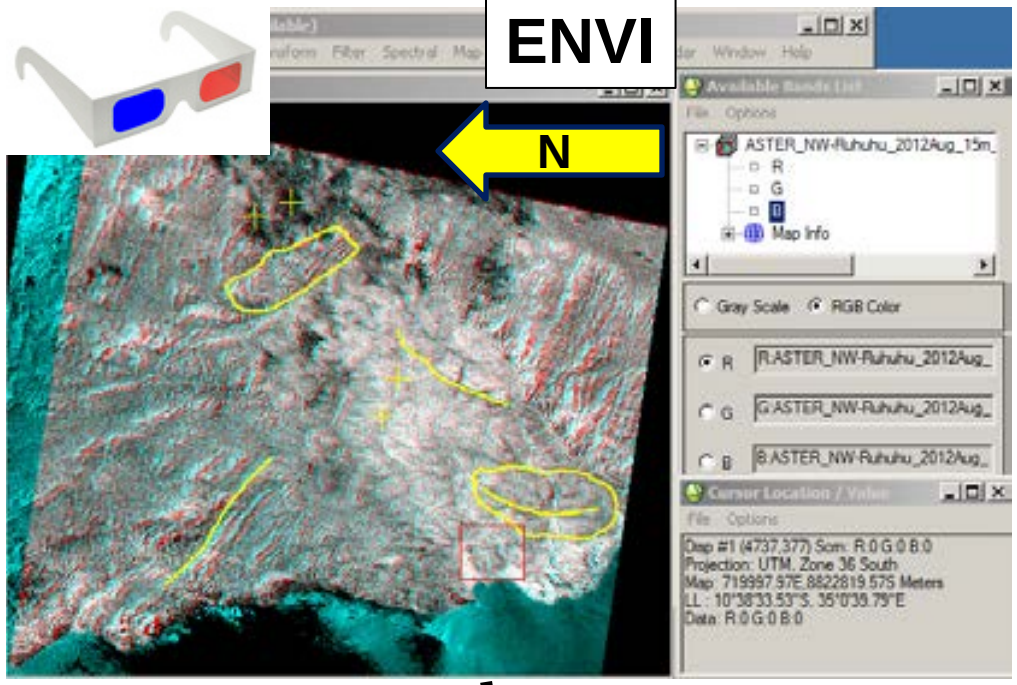
Overlapping images enable stereoscopic viewing



ASTER Stereo from Overlapping Band 3 (NIR) Nadir & Off-Nadir Images

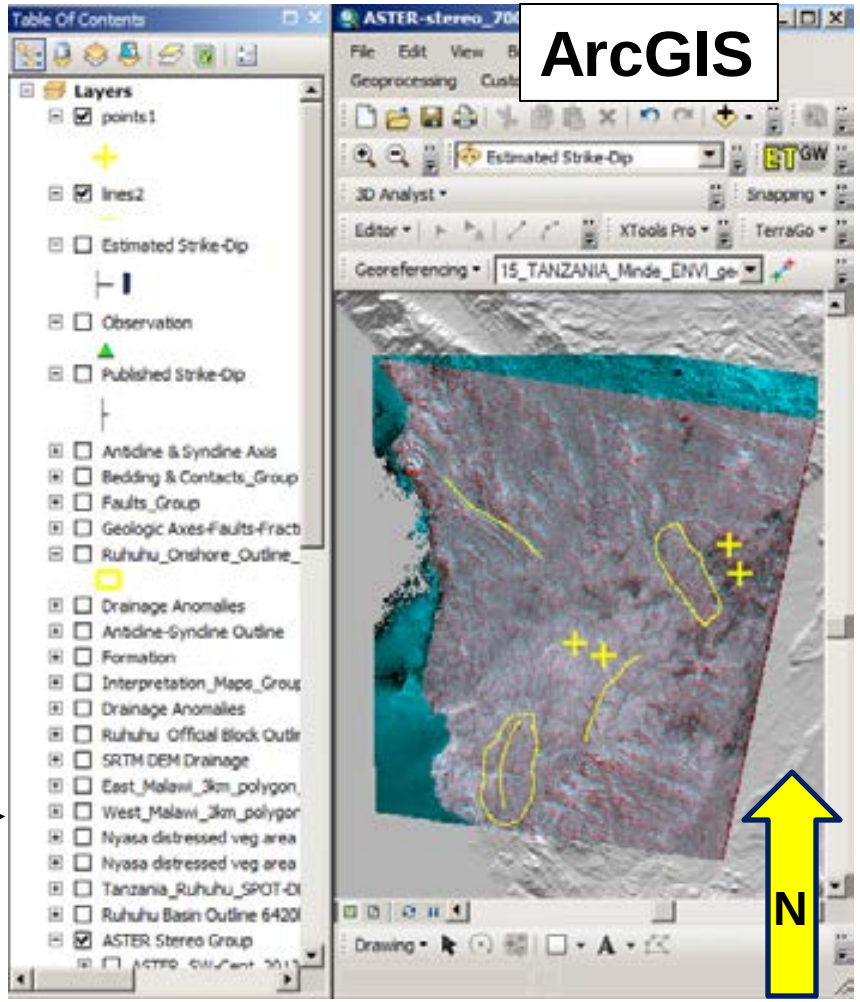


ASTER Stereo Mapping Work Process

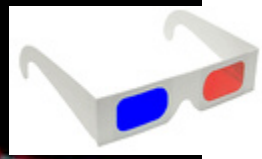


ASTER stereo model rotated 90° and interpreted with red/cyan glasses. Coordinates preserved! Vector maps created.

Stereo interpretation (vector maps) loads into GIS in correct map space!



Overlapping ASTER images

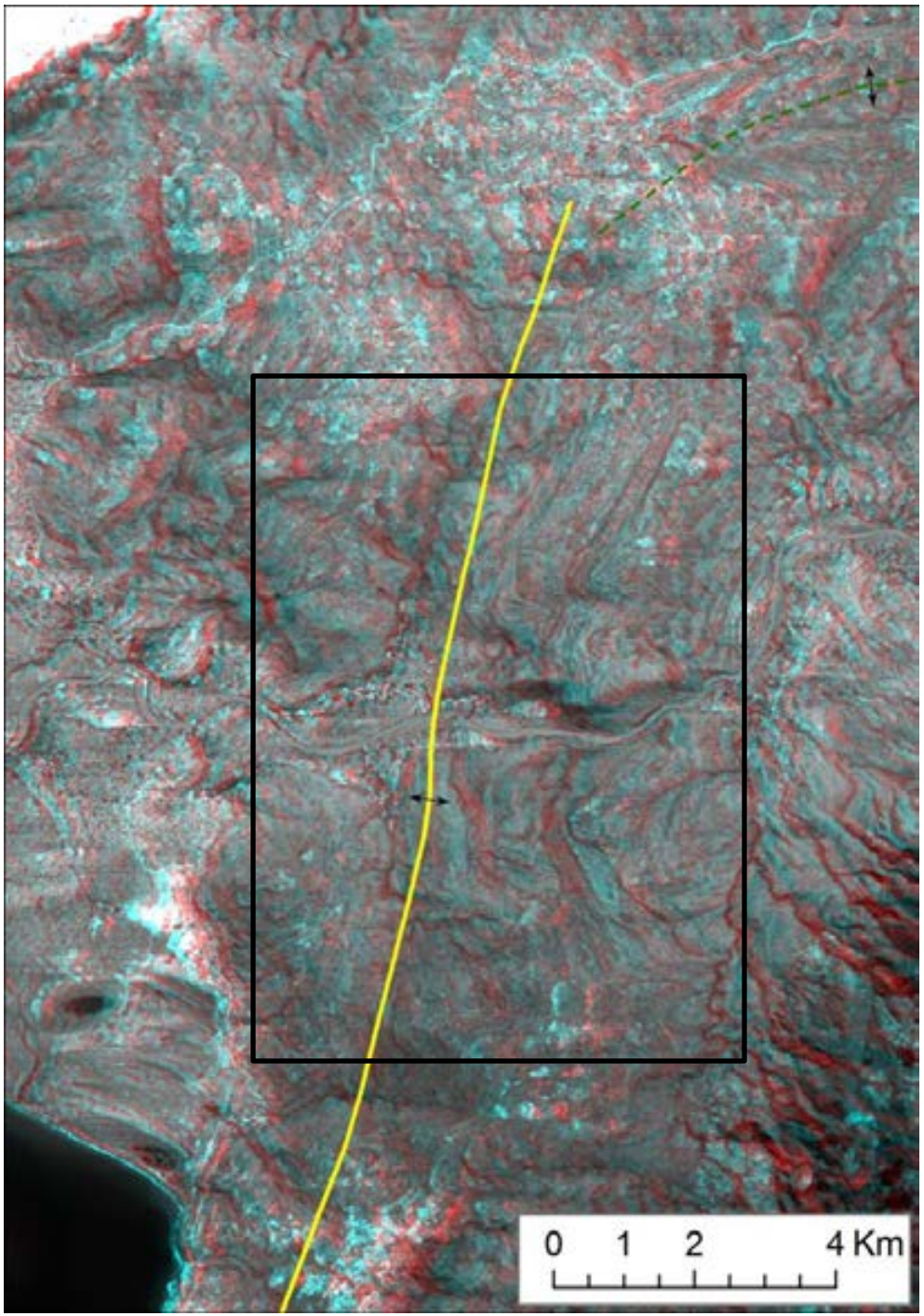


N

N

Landsat 15 meter
Pan image draped
On STRM DEM

8X vertical
exaggeration



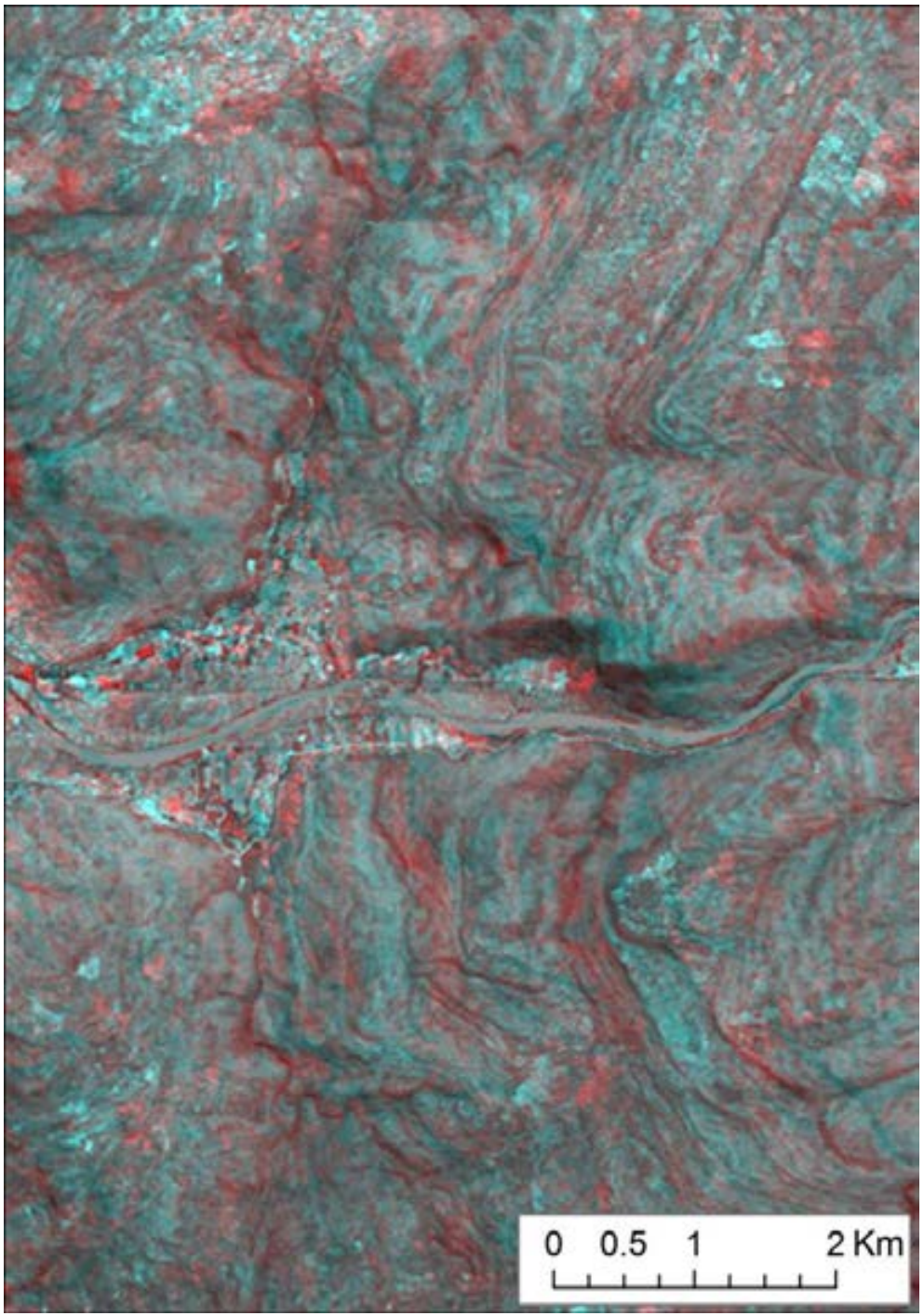
Synthetic Stereo DEM

Viewed in ArcGIS

N

Landsat 15 meter
Pan image draped
On STRM DEM

8X vertical
exaggeration

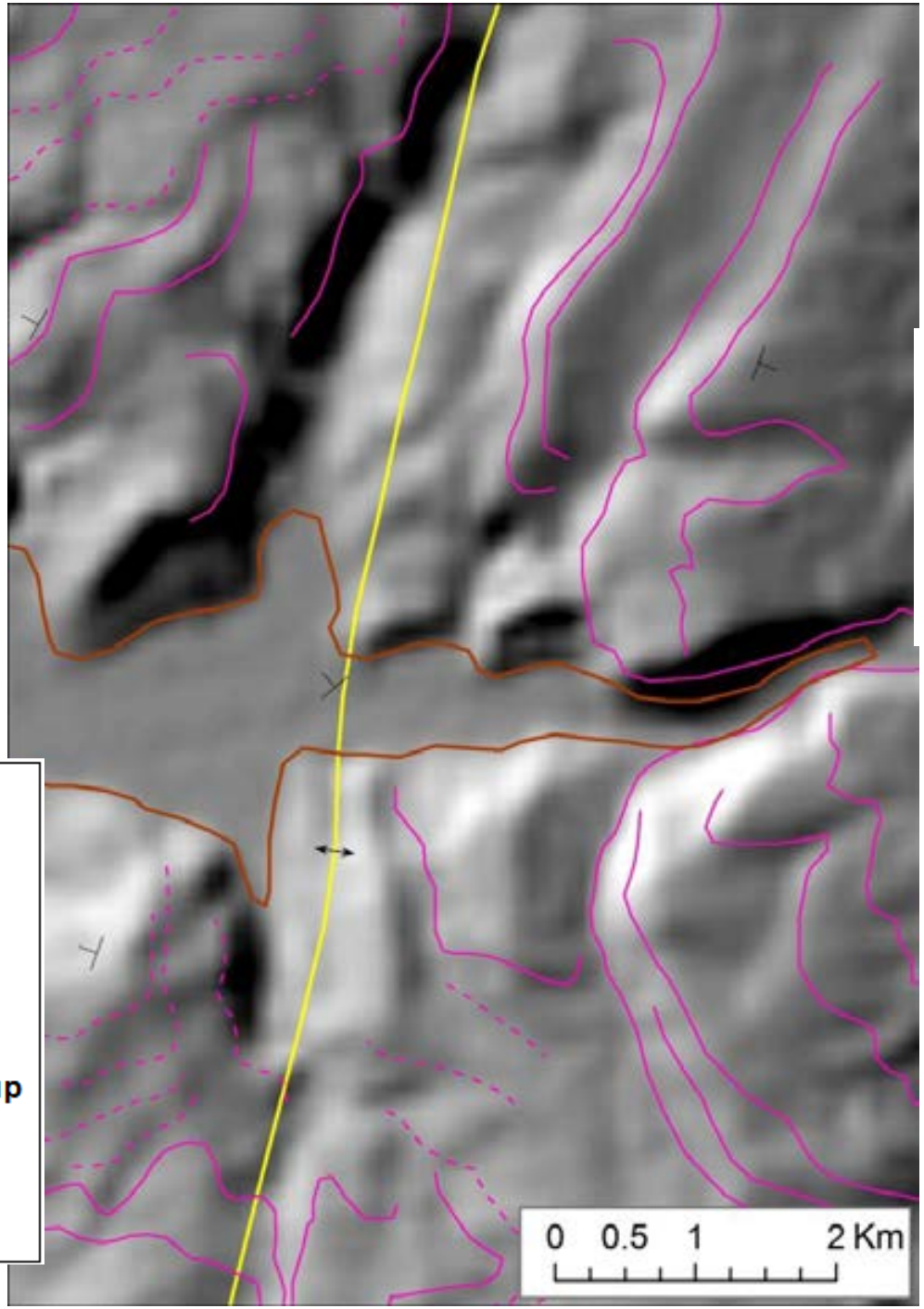


Synthetic Stereo DEM

Viewed in ArcGIS

Hillshade SRTM DEM

Difficult to estimate dips accurately.



DEM grid size controls quality of dip estimates from Synthetic Stereo DEMs

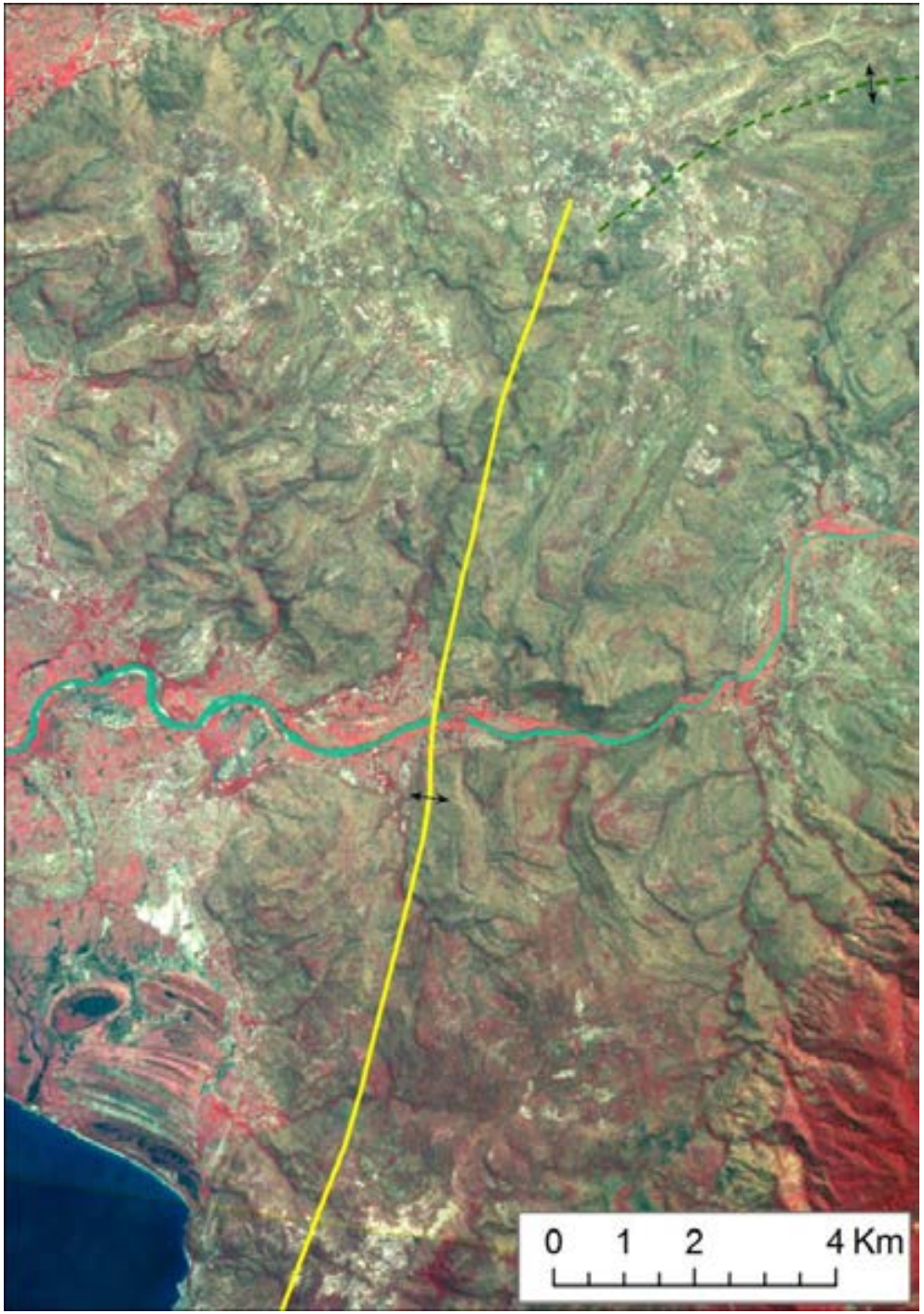
Landcover?
Type of DEM?

Top of canopy (DSM)
vs.
Bare Earth ($) DTM

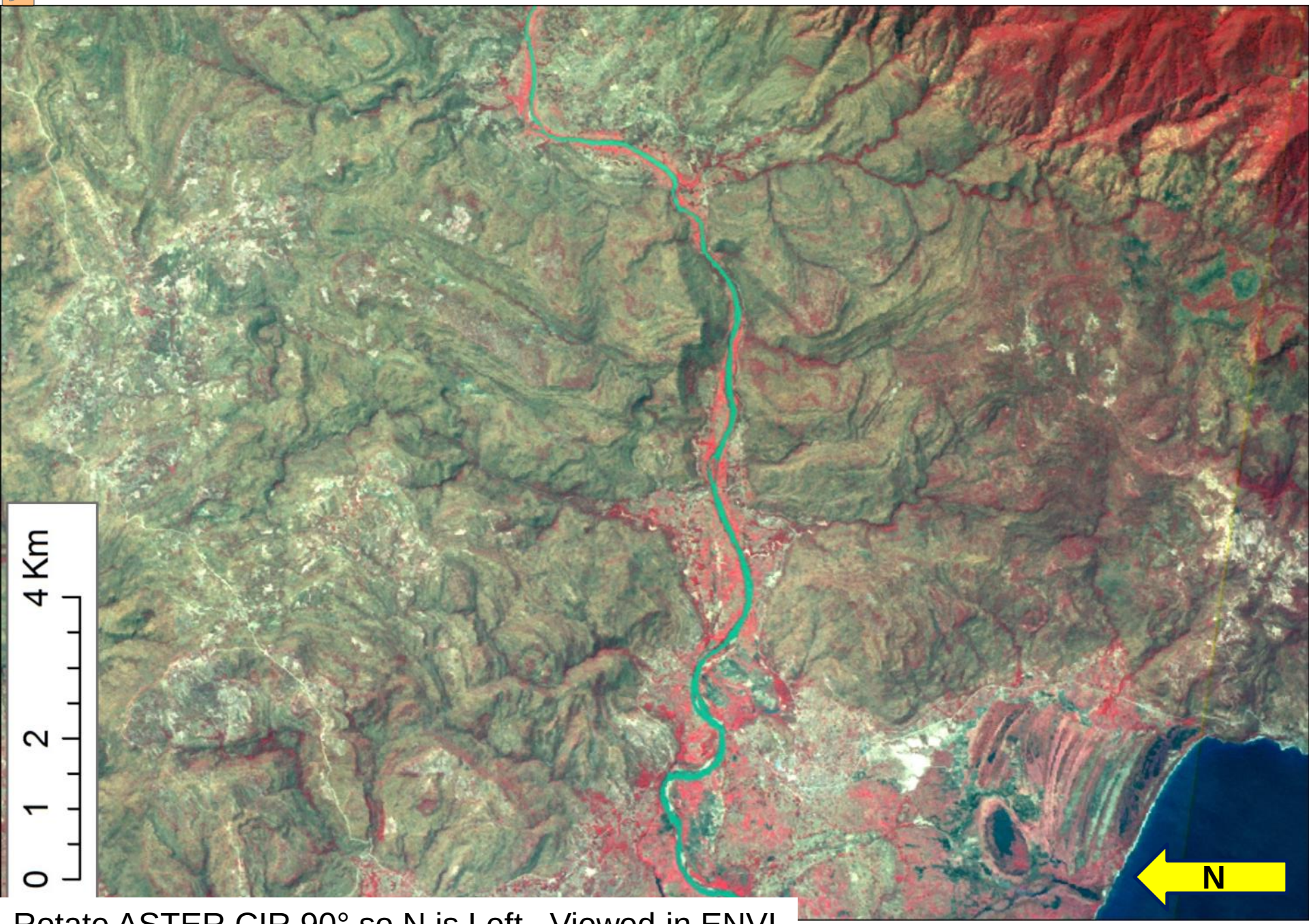
N

ASTER 15 m
CIR image

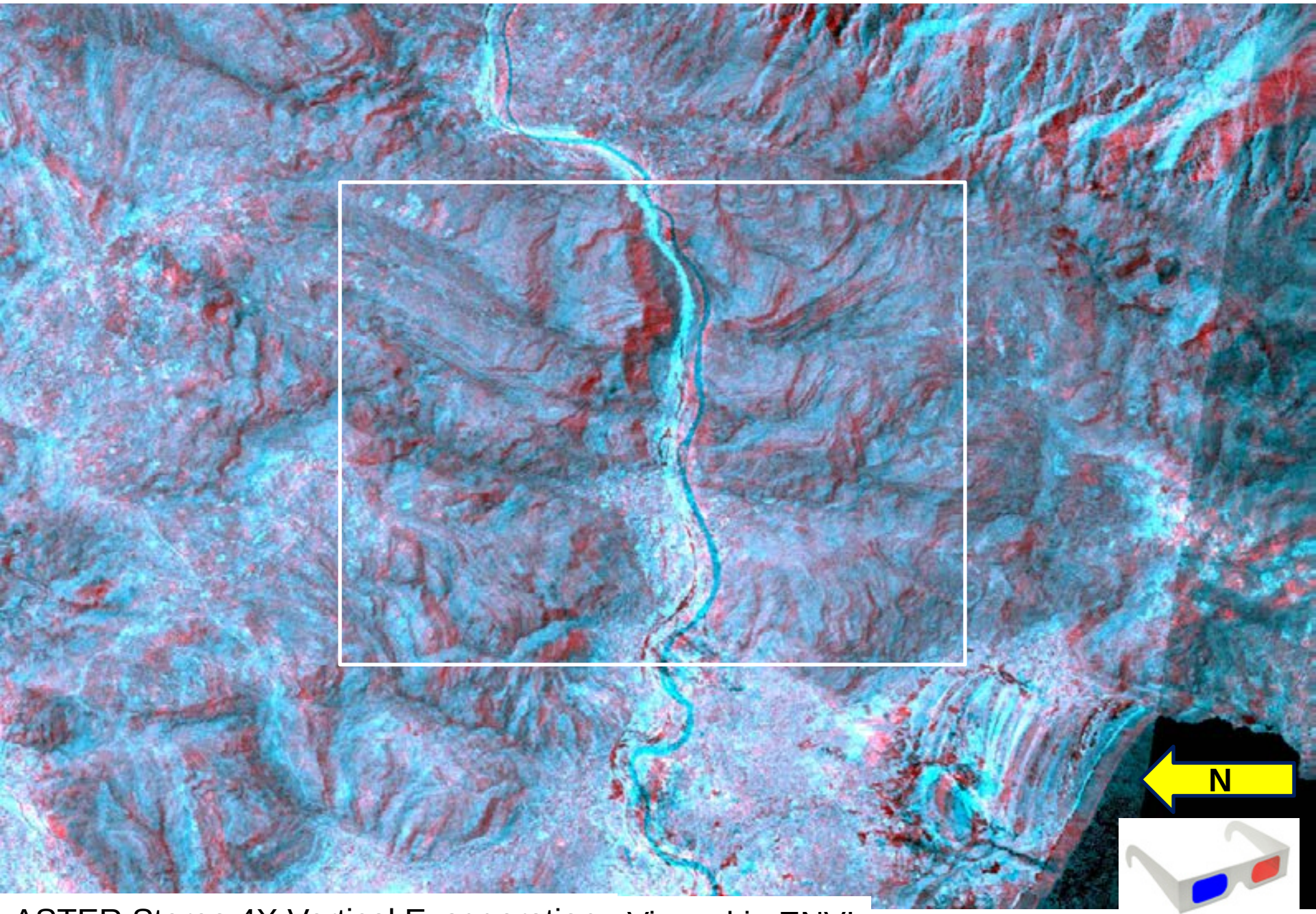
Anticline Axis
Yellow line



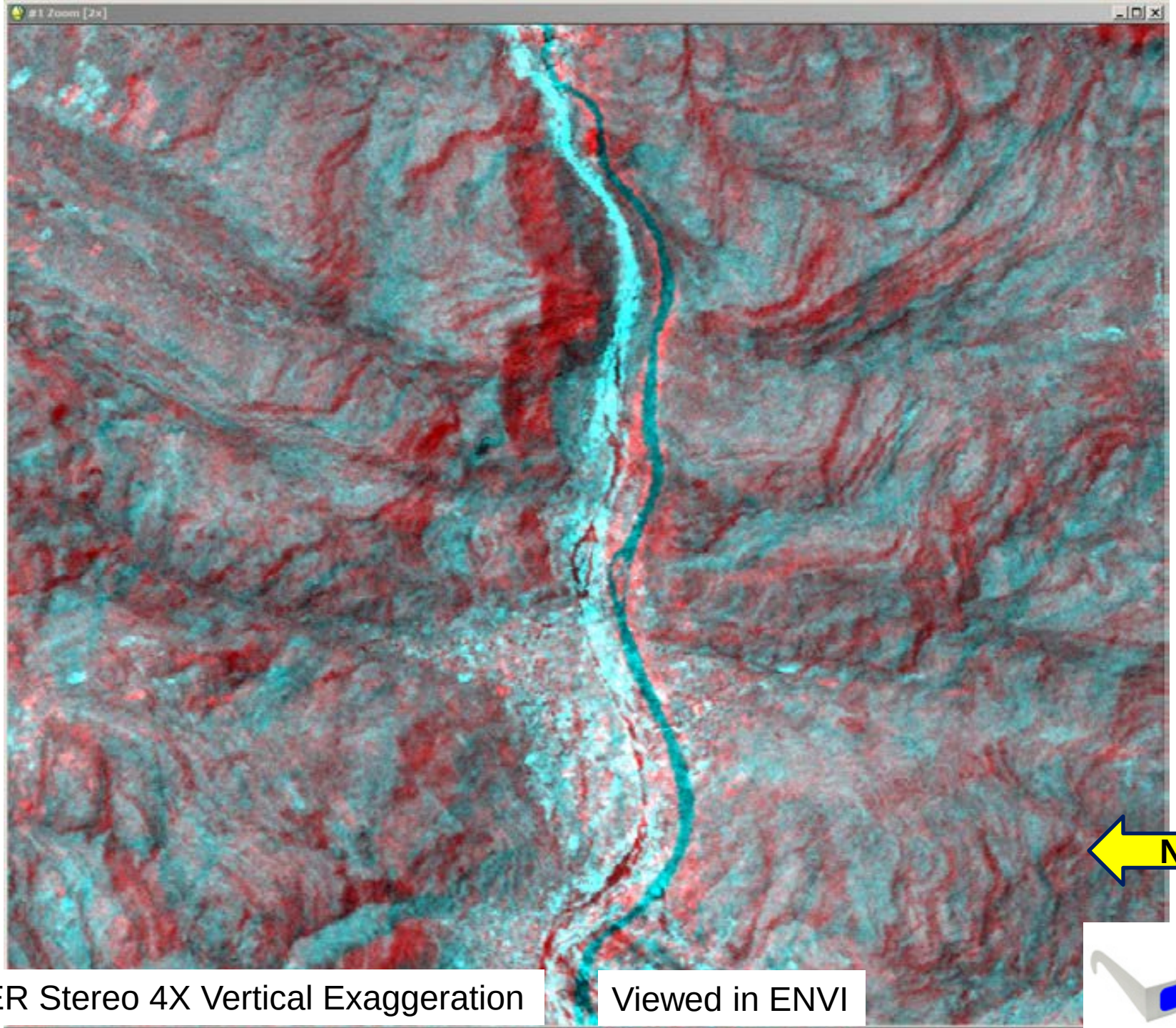
Viewed in ArcGIS



Rotate ASTER CIR 90° so N is Left. Viewed in ENVI



ASTER Stereo 4X Vertical Exaggeration Viewed in ENVI

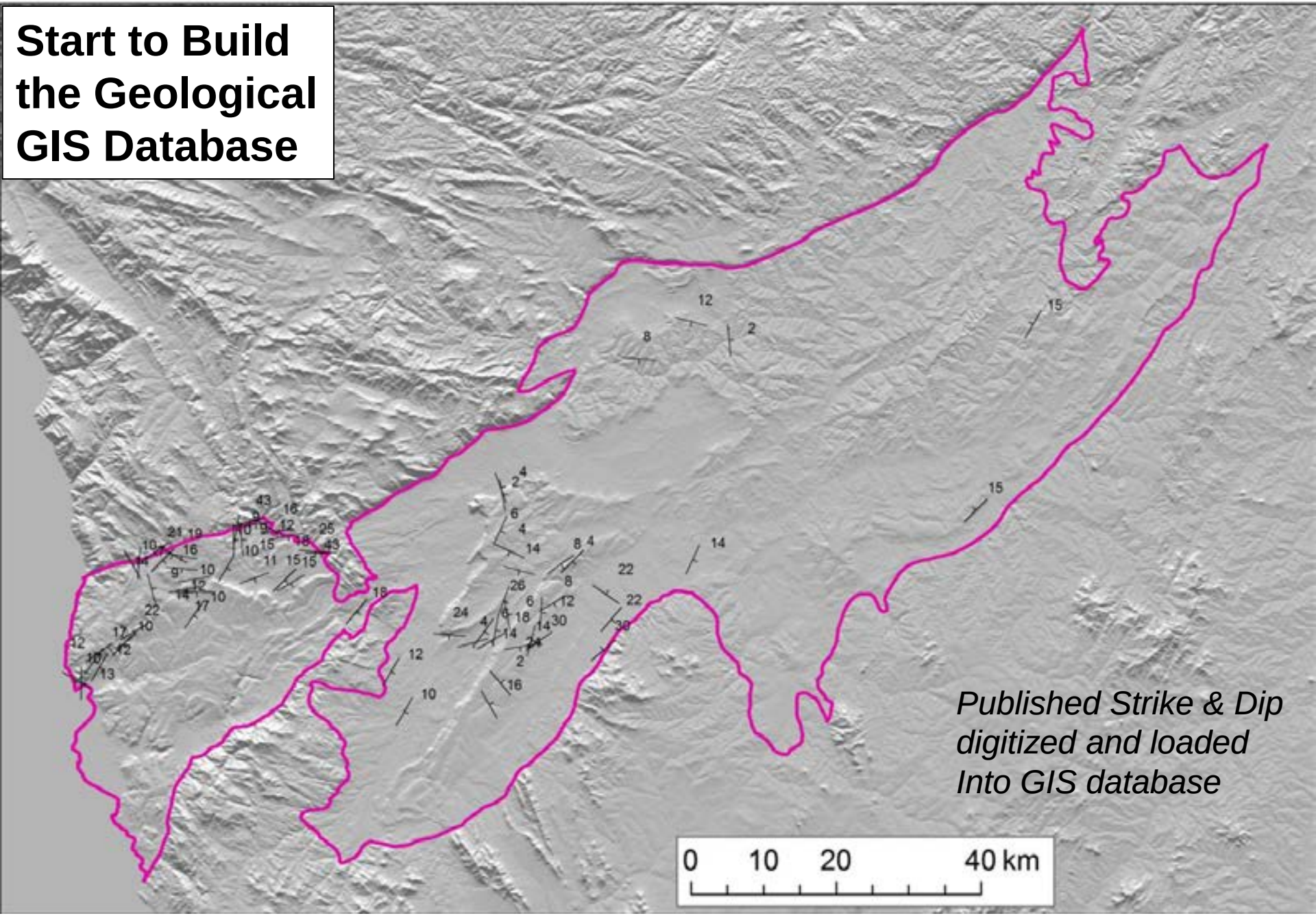


ASTER Stereo 4X Vertical Exaggeration

Viewed in ENVI

Published Strike & Dip

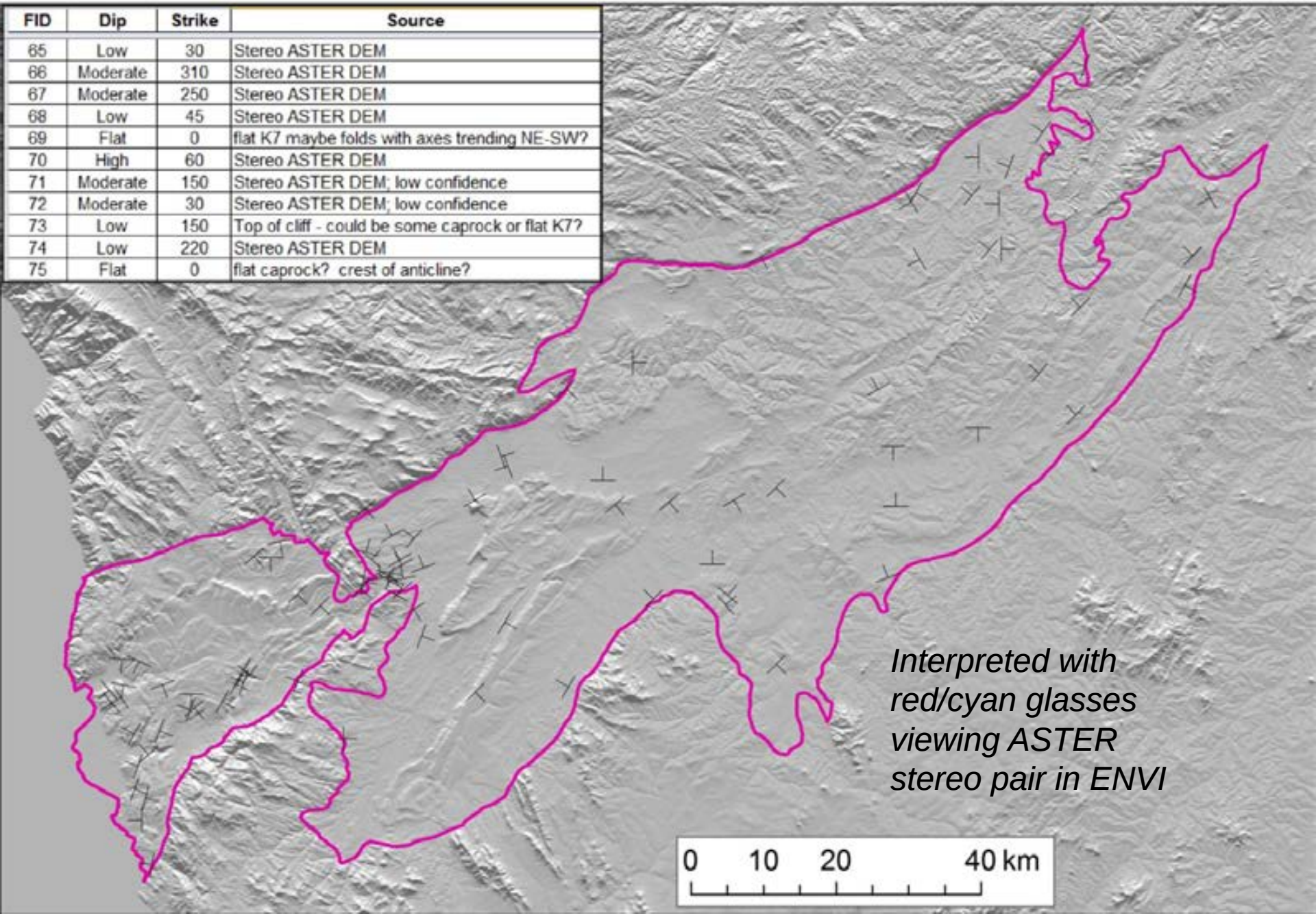
Start to Build the Geological GIS Database



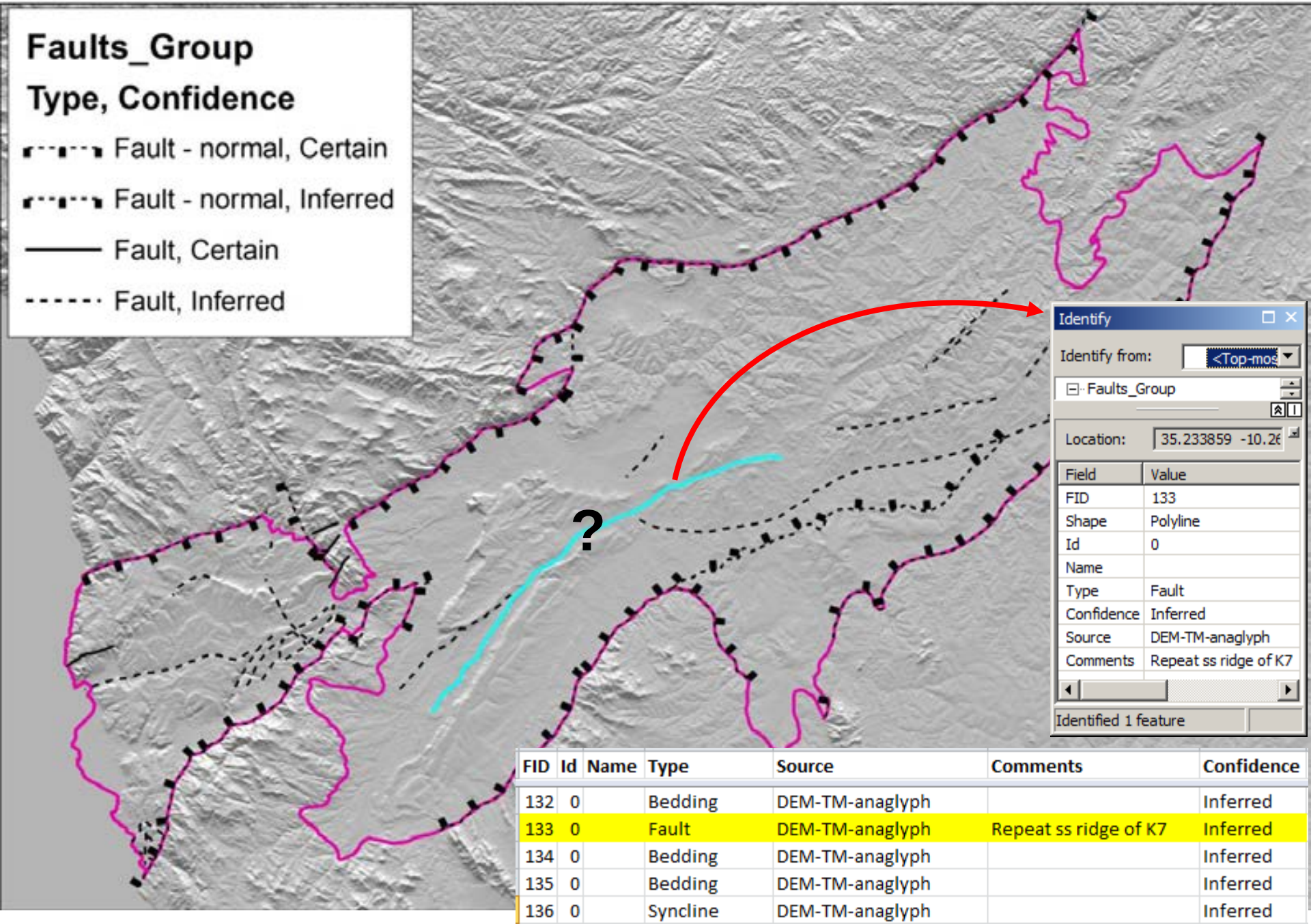
Published Strike & Dip digitized and loaded Into GIS database

Estimated Strike & Dip

FID	Dip	Strike	Source
65	Low	30	Stereo ASTER DEM
66	Moderate	310	Stereo ASTER DEM
67	Moderate	250	Stereo ASTER DEM
68	Low	45	Stereo ASTER DEM
69	Flat	0	flat K7 maybe folds with axes trending NE-SW?
70	High	60	Stereo ASTER DEM
71	Moderate	150	Stereo ASTER DEM; low confidence
72	Moderate	30	Stereo ASTER DEM; low confidence
73	Low	150	Top of cliff - could be some caprock or flat K7?
74	Low	220	Stereo ASTER DEM
75	Flat	0	flat caprock? crest of anticline?

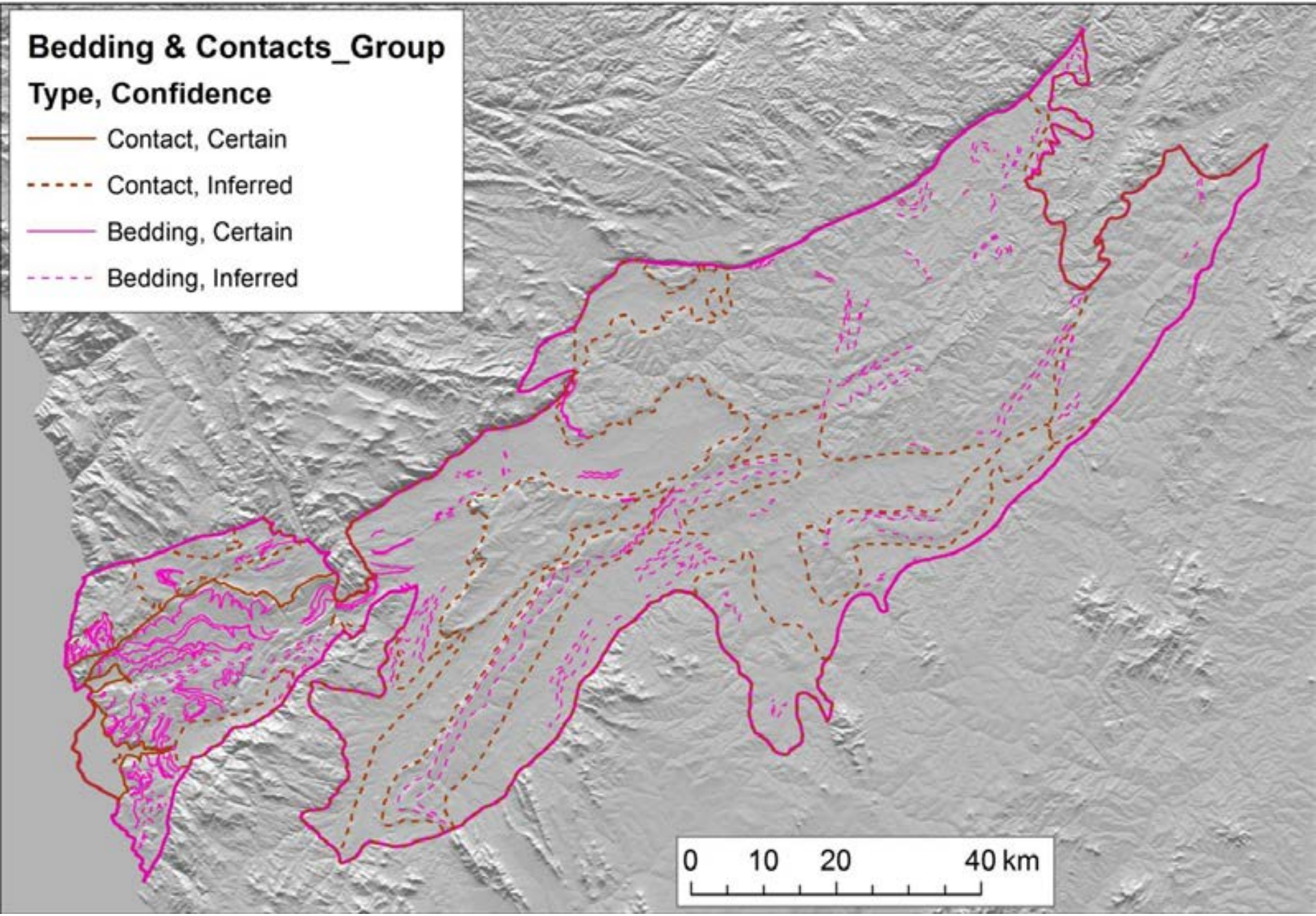


Attribute polygons, lines & points as you map!

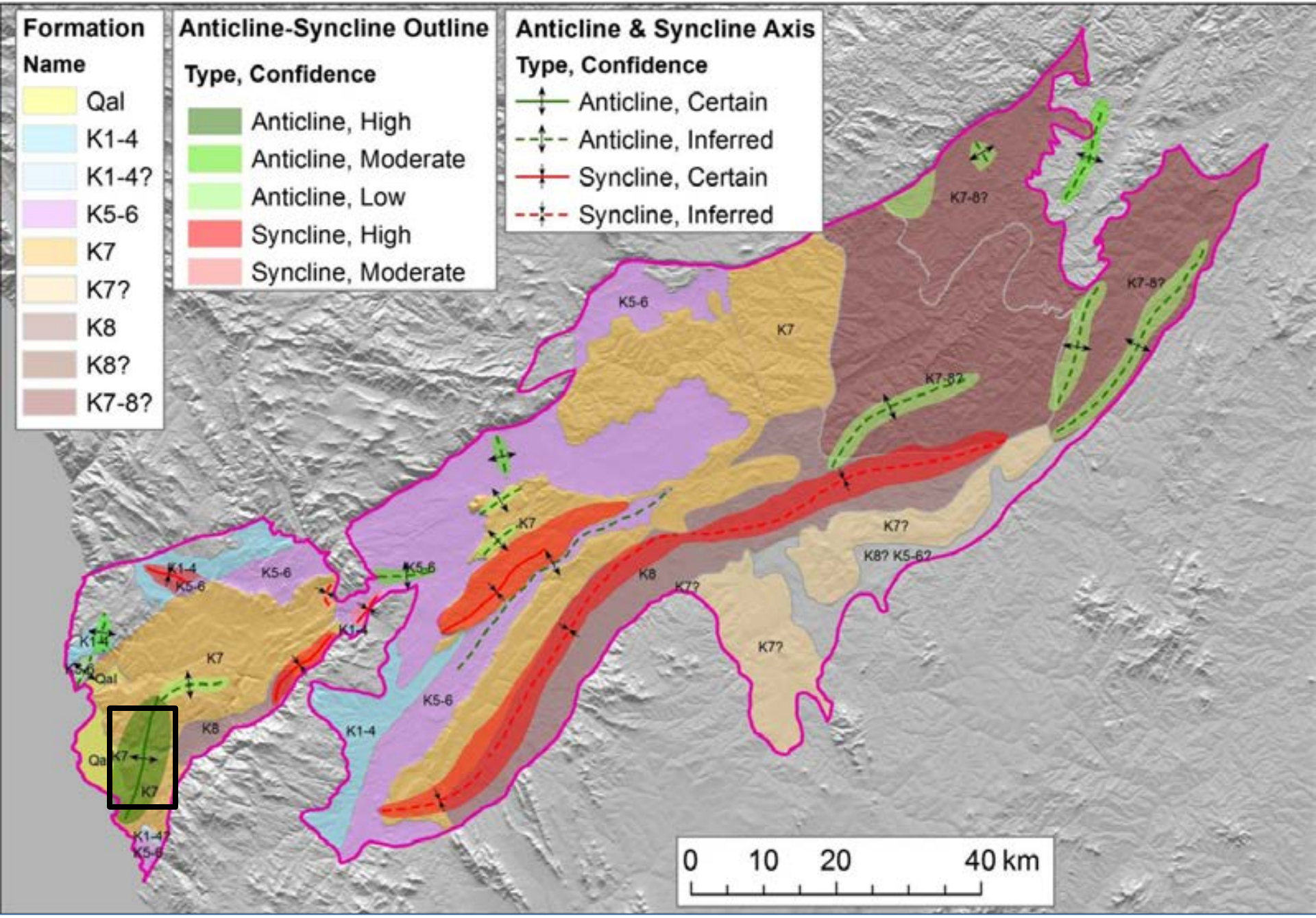


FID	Id	Name	Type	Source	Comments	Confidence
132	0		Bedding	DEM-TM-anaglyph		Inferred
133	0		Fault	DEM-TM-anaglyph	Repeat ss ridge of K7	Inferred
134	0		Bedding	DEM-TM-anaglyph		Inferred
135	0		Bedding	DEM-TM-anaglyph		Inferred
136	0		Syncline	DEM-TM-anaglyph		Inferred

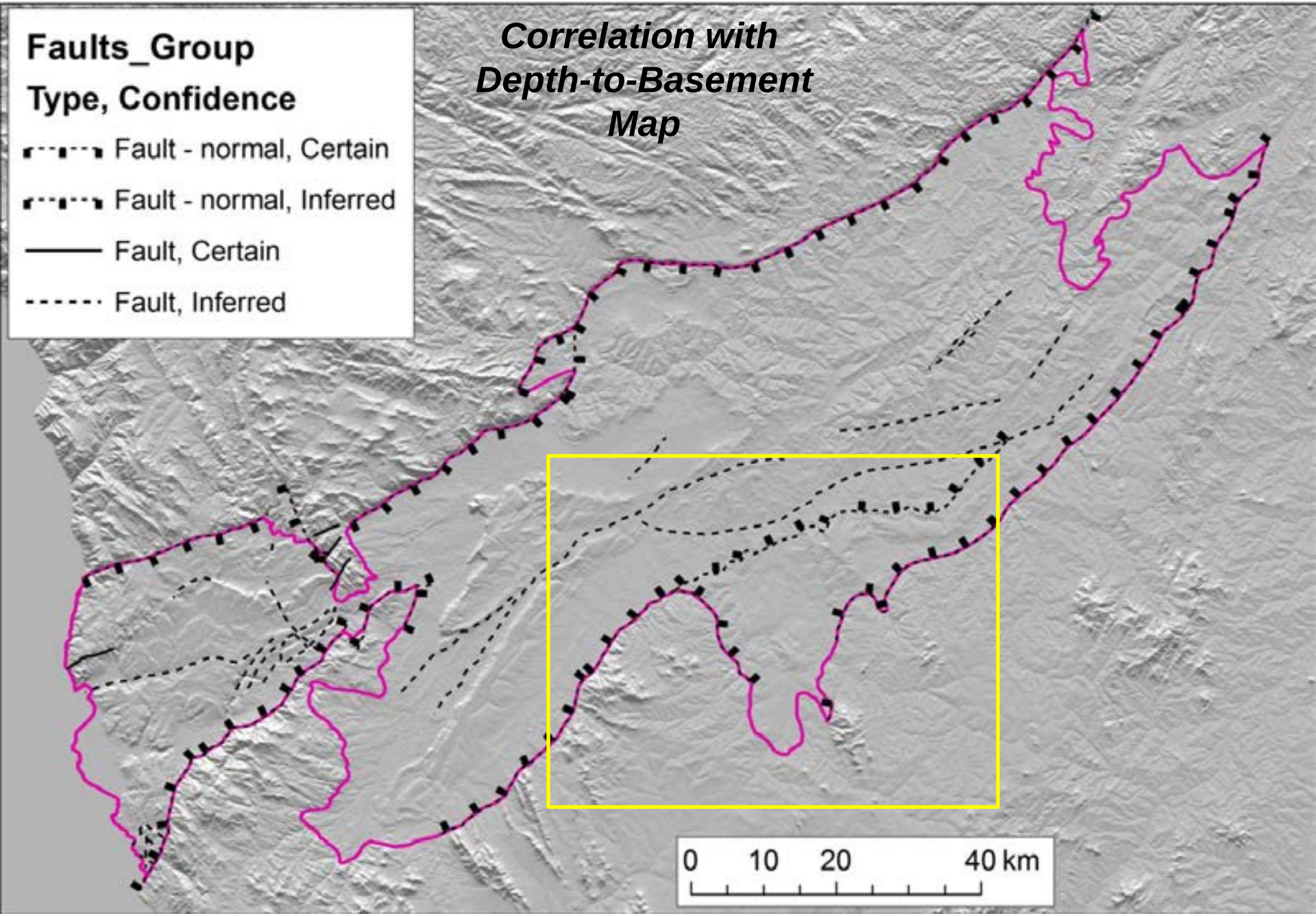
Bedding & Contacts



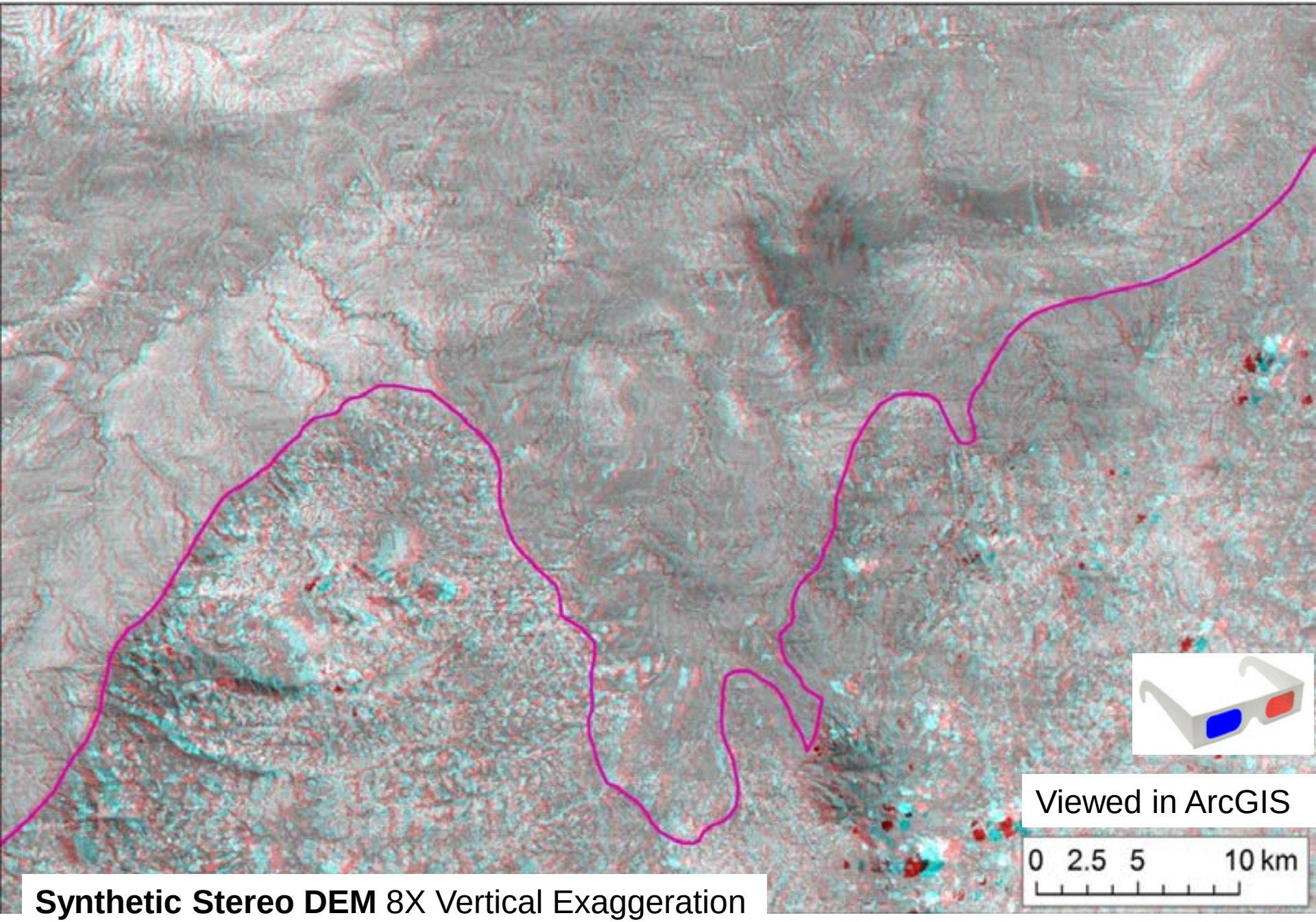
Interpreted Anticlines & Synclines, Formations



Interpreted Faults



Landsat Pan + SRTM DEM 8X Anaglyph along Southern Margin

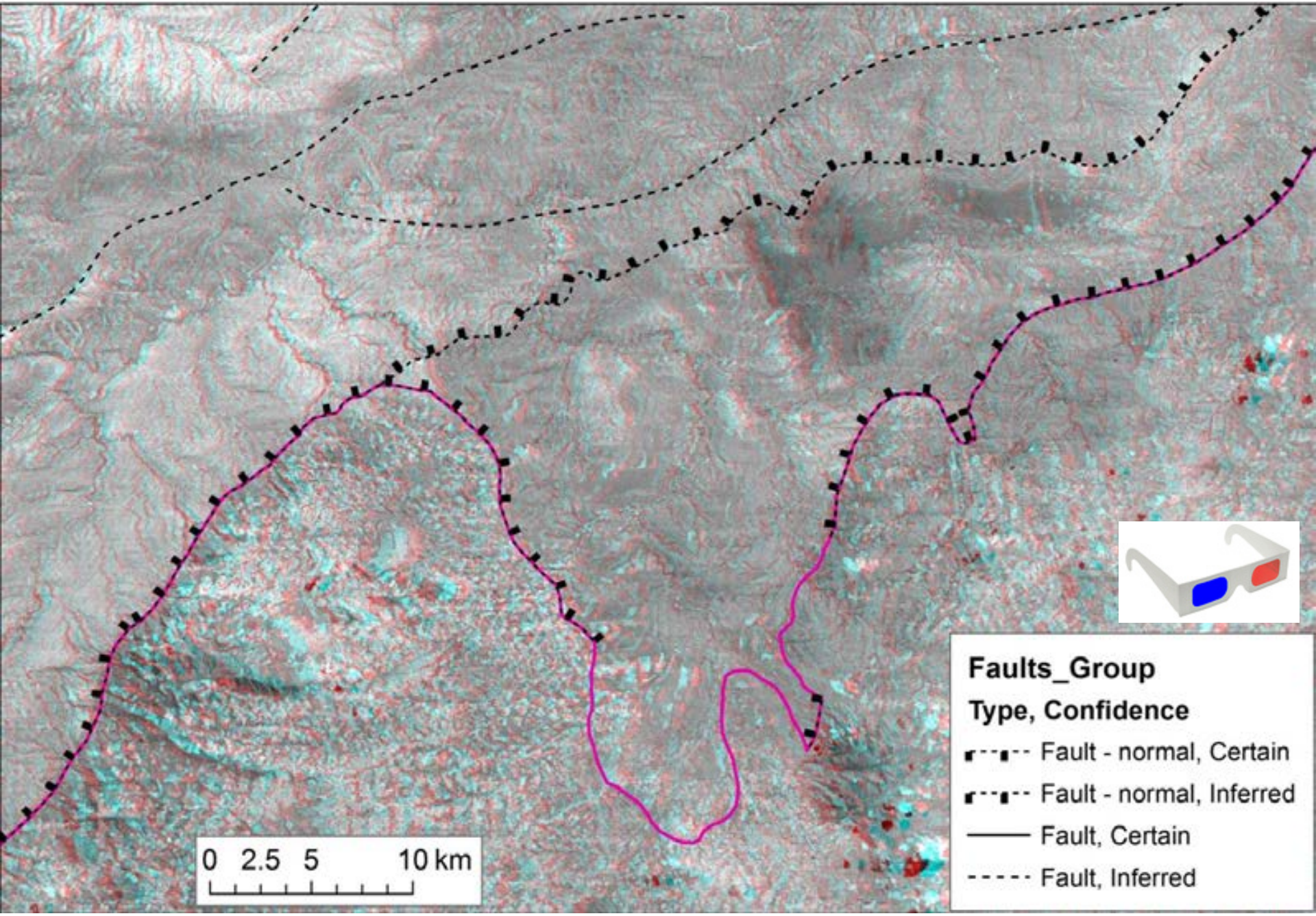


Viewed in ArcGIS

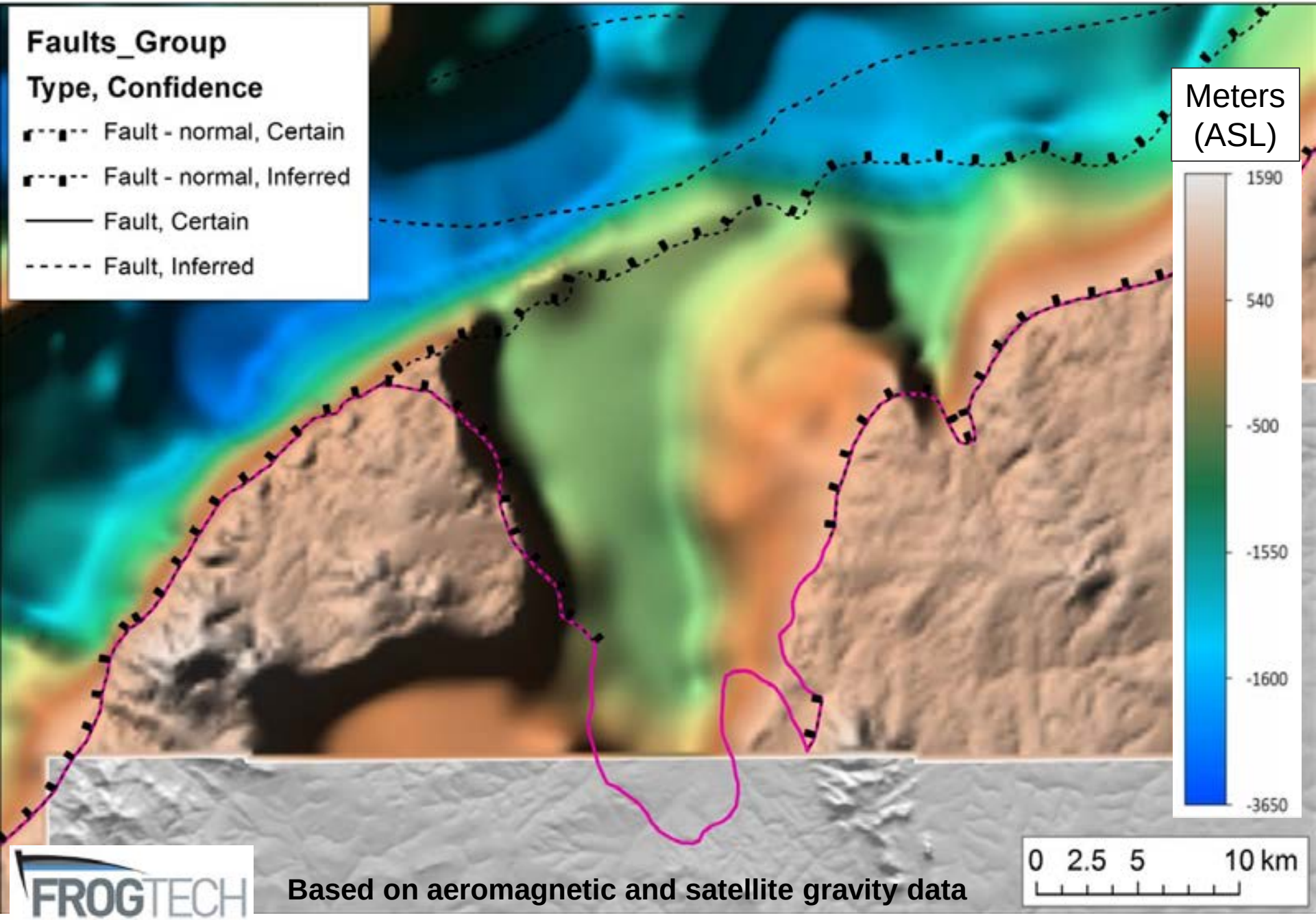
0 2.5 5 10 km

Synthetic Stereo DEM 8X Vertical Exaggeration

Faults with Landsat Pan + SRTM DEM 8X Anaglyph along Southern Margin



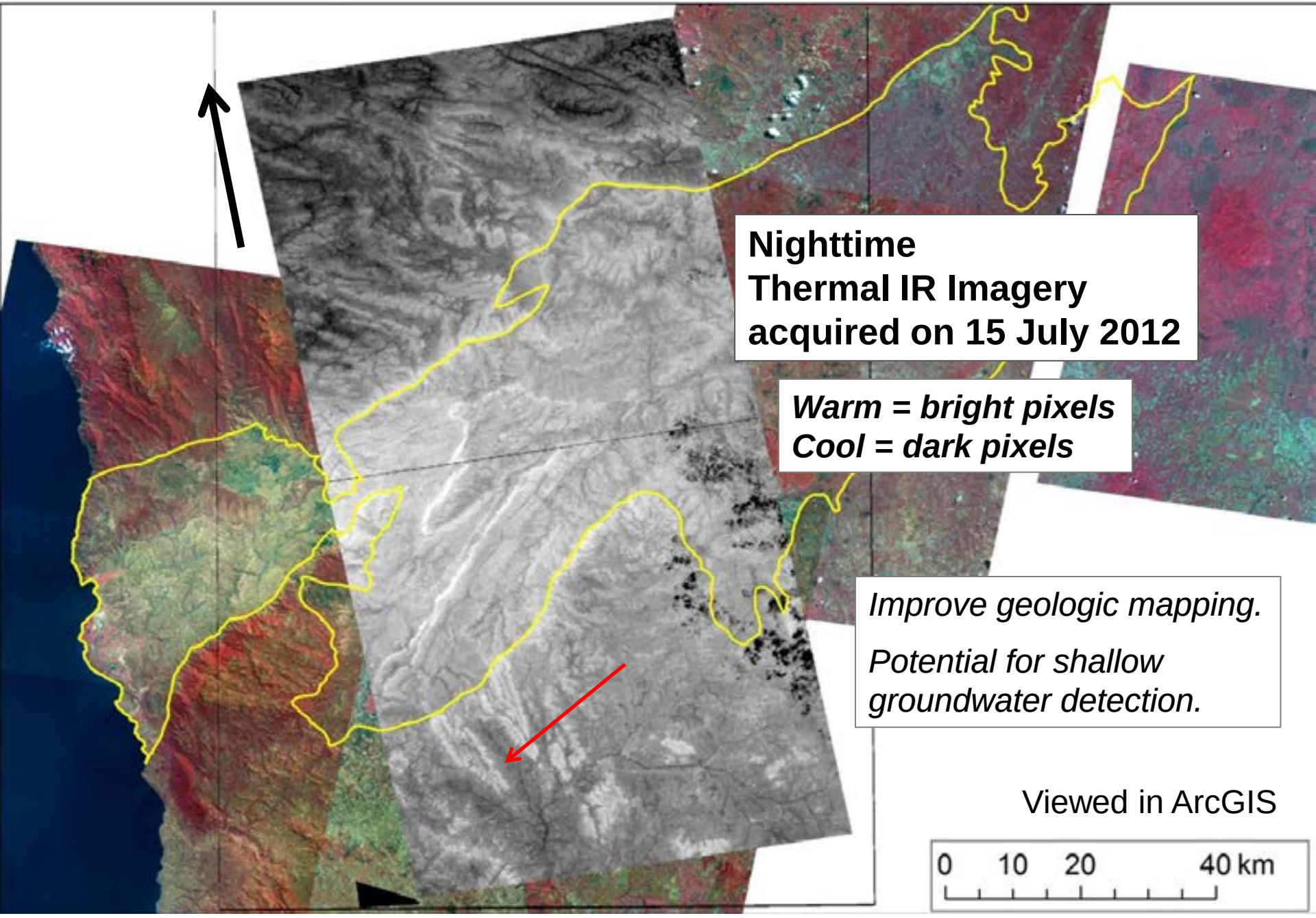
Interpreted Fault Correlates with Depth to Basement Map



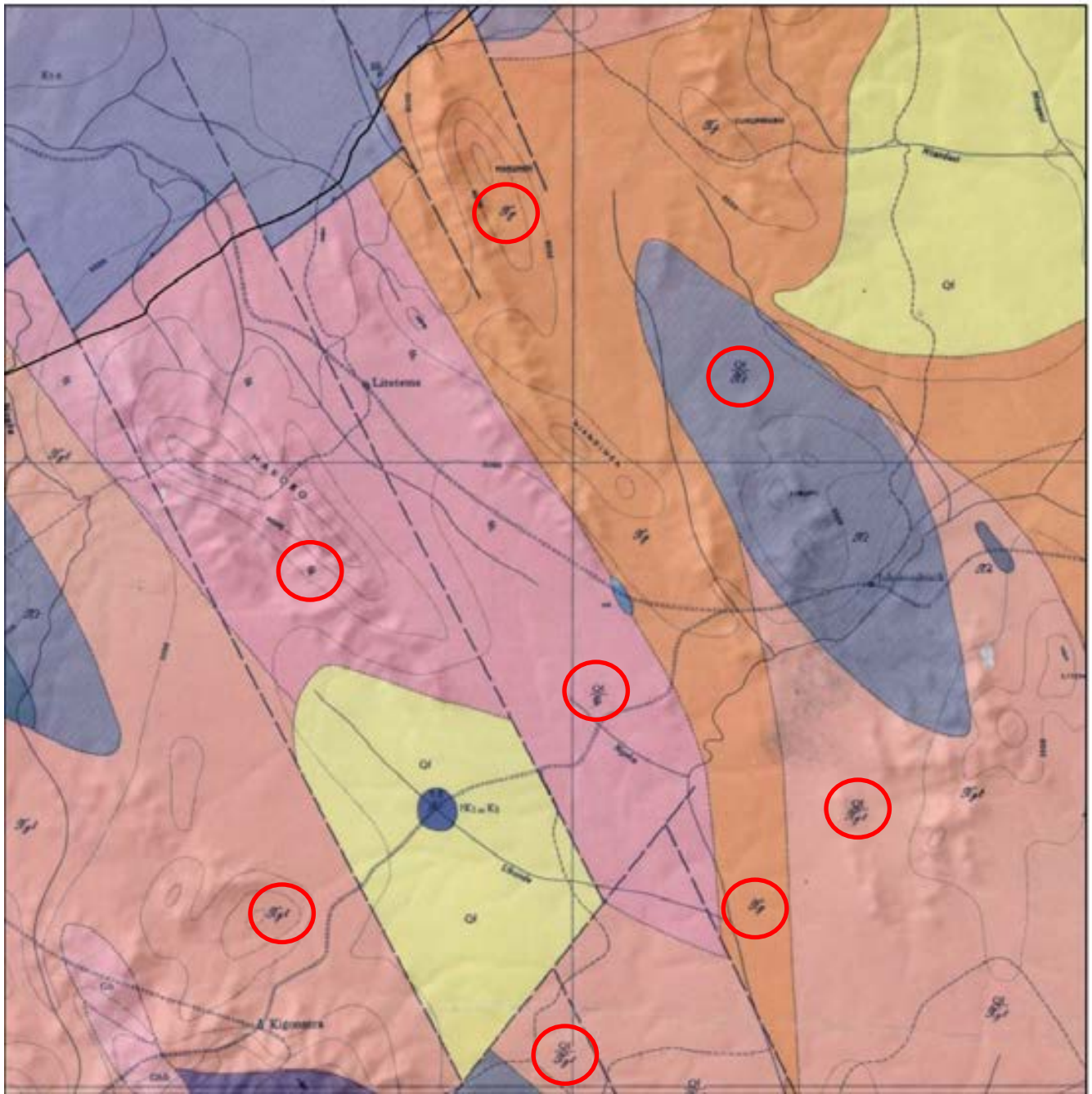
FROGTECH

Based on aeromagnetic and satellite gravity data

ASTER Nighttime Surface Temperature Images (AST_08)



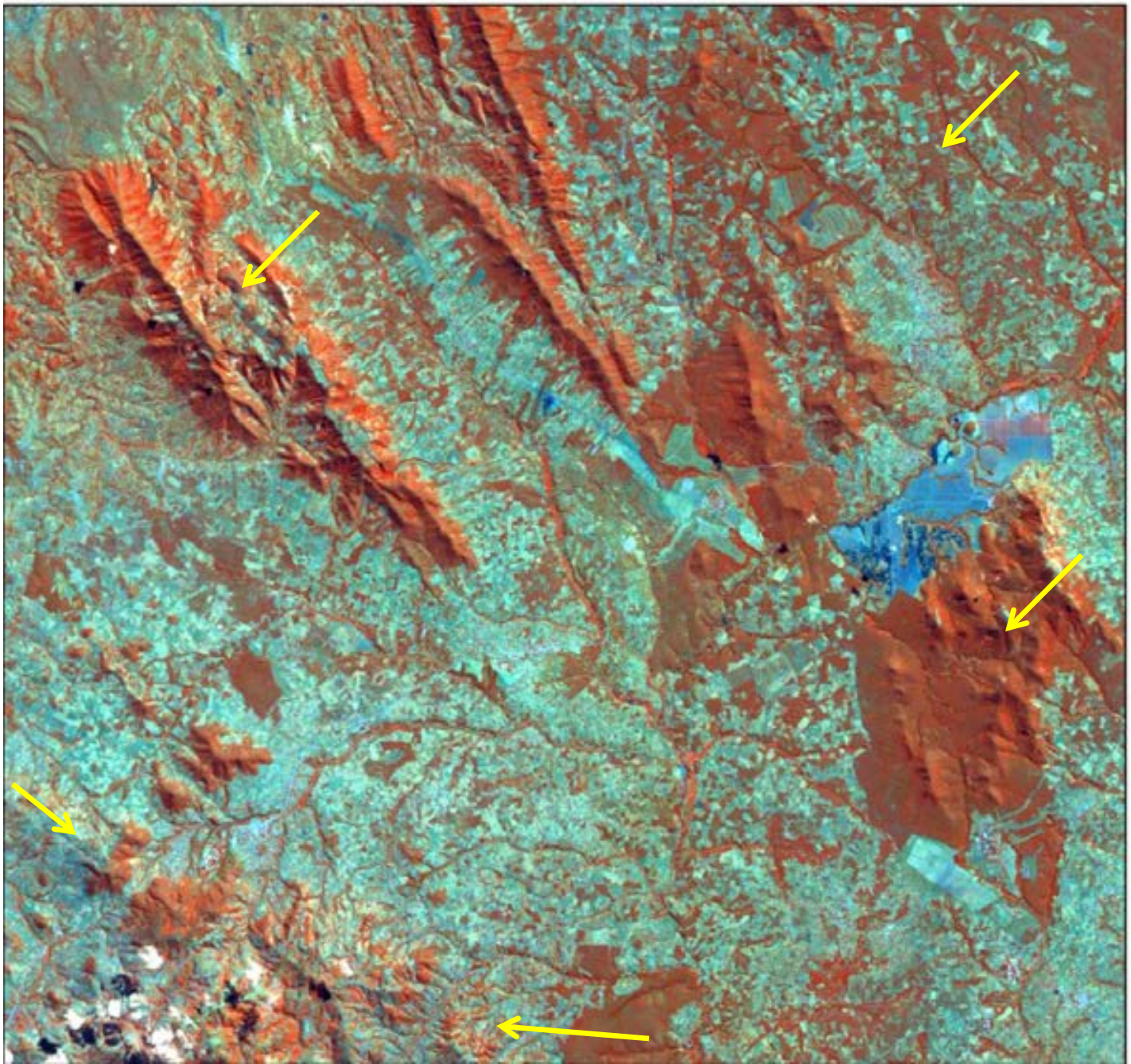
Published 1:100,000 Geologic Map



Geologist identified igneous & metamorphic rocks - over 600,000,000 years old.

0 2 4 8 km

Landsat OLI Total IR Bands 5-6-7 as R-G-B

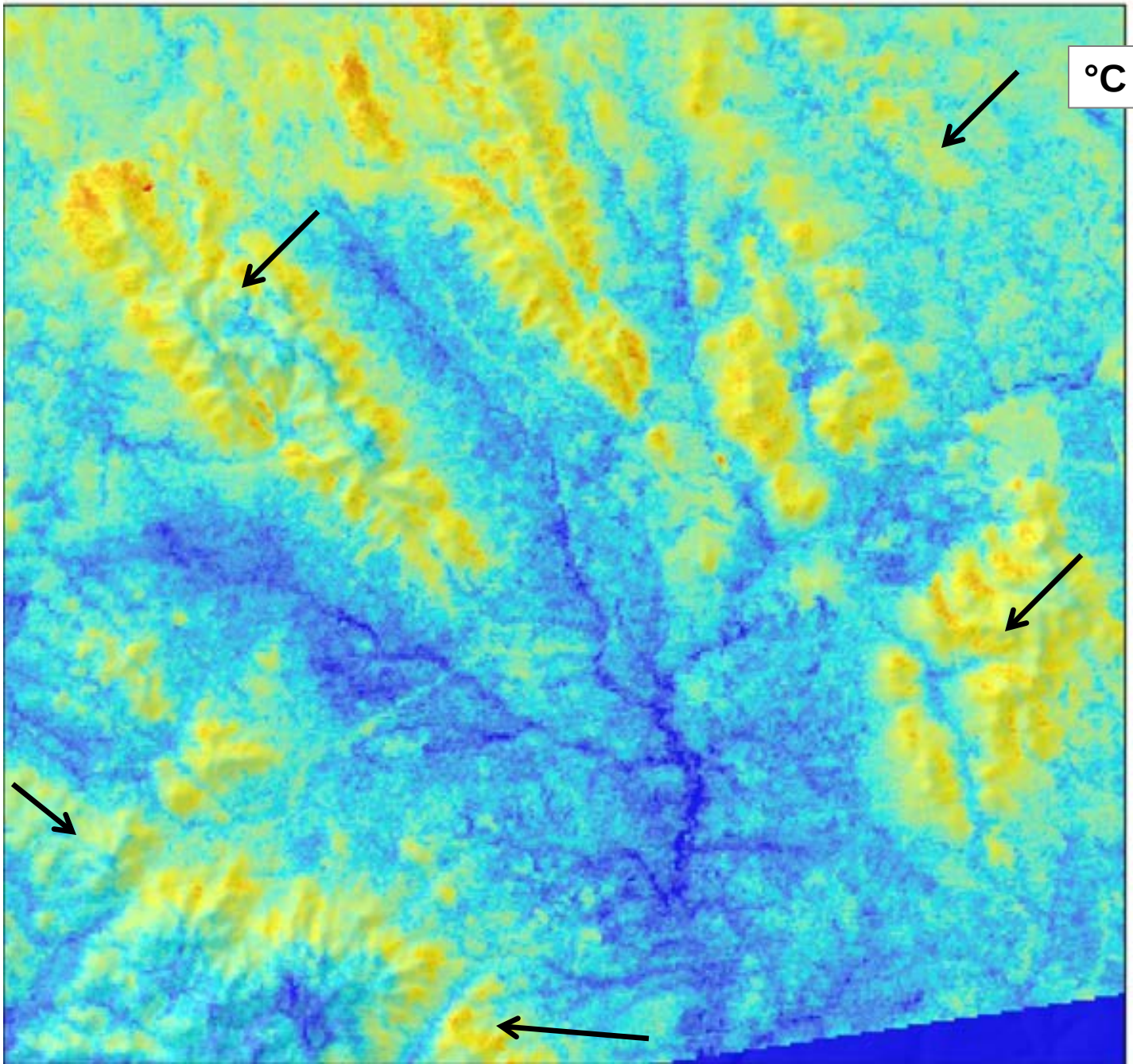


Tough place to map geology.

Agriculture & vegetated terrain.

0 2 4 8 km

ASTER Nighttime Surface Temperature Images (AST_08)



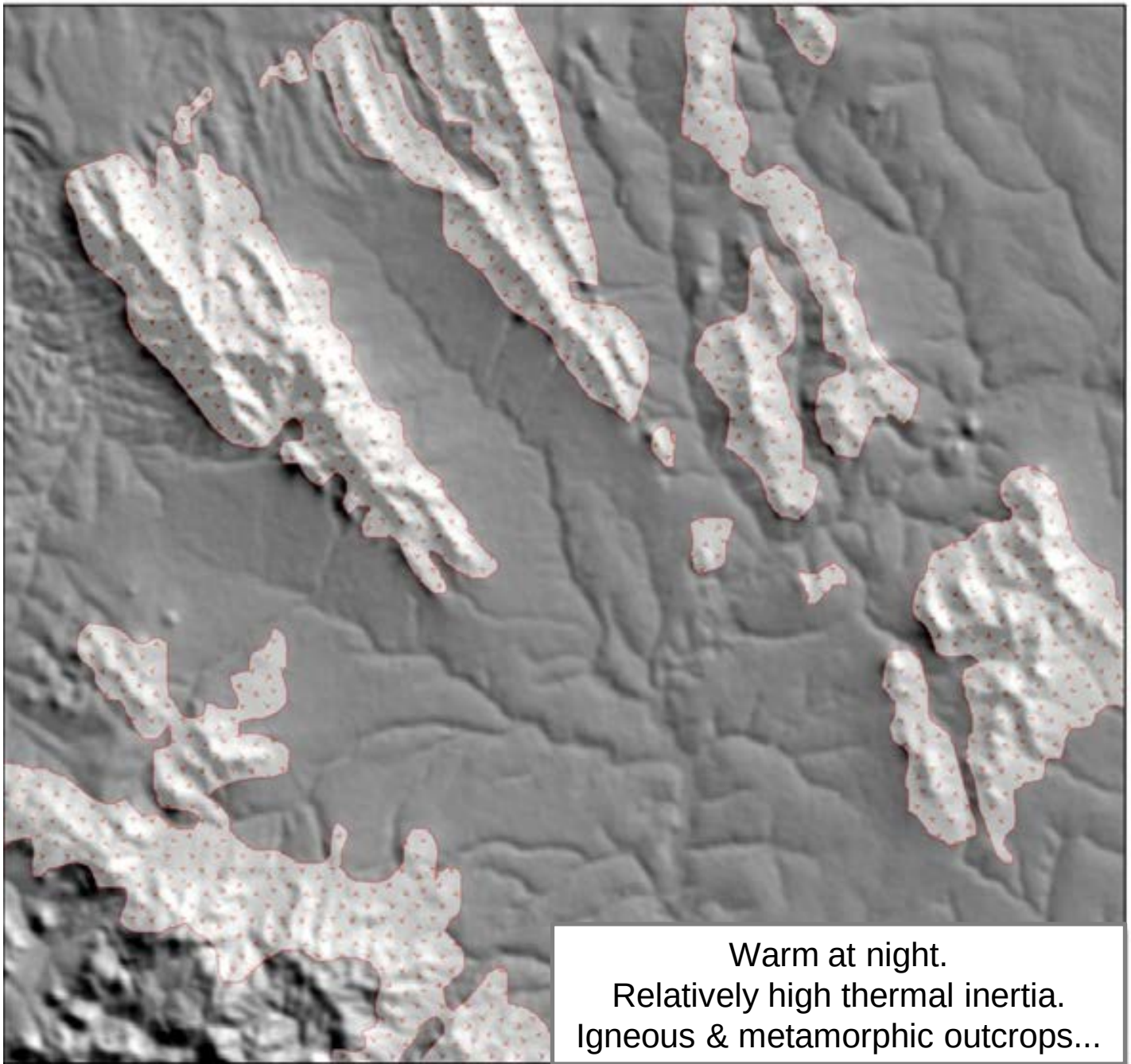
°C = (DN – 2730) * 0.1

Temperature
Celsius (C)
> = 24
< = 10

15 July 2012

0 2 4 8 km

Interpretation of ASTER Nighttime TIR Temperature Image (AST_08)



Similar Temperature

Warm at night.
Relatively high thermal inertia.
Igneous & metamorphic outcrops...

0 2 4 8 km

In Conclusion – Some Best Practices For Exploration:

- **Download & Evaluate as many images as possible.**
  - ***NEW* Sentinel-2, Sentinel-1, PALSAR-2, WV-3 VNIR-SWIR ($)**
- **Leverage DEMs and stereo mapping.**
  - **Synthetic Stereo DEMs (Change V. E., Dependent on DEM).**
  - **Overlapping imagery (creates a true Stereo Model).**
- **Attribute interpretation polygons, polylines & points *while* mapping.**
  - **Enables informative & useful map symbology.**
- **Build a GIS database.**

Acknowledgements

Landsat, SRTM, ASTER VNIR Courtesy of USGS.

ASTER TIR (AST_08) Courtesy NASA LP DAAC (EarthData).

Software: *Harris ENVI, ESRI ArcGIS Desktop, Hexagon ERDAS Imagine, RiverTools.*

The End

Questions? Comments?

jellis@ellis-geospatial.com

www.ellis-geospatial.com

Keep the stereo glasses – give them to a young person and direct them to NASA's Mars 3D website.

check the ad on the side….

New College Textbook available Early 2020!

Remote Sensing Principles, Interpretation and Applications, 4th Ed.

Floyd Sabins & James Ellis

17 Chapters (6 new) – Geology, DEMs, GIS, drones, renewables, environment, climate, etc.
483 B&W Figures (54% new), 81 color images (86% new).
Remote Sensing Digital Database – 6 GB, 27 examples organized by textbook chapters.
Download multispectral, thermal IR, radar, hyperspectral , drone data.
Image Processing Lab Manual (12 step-by-step exercises) using textbook examples.

Ellis GeoSpatial