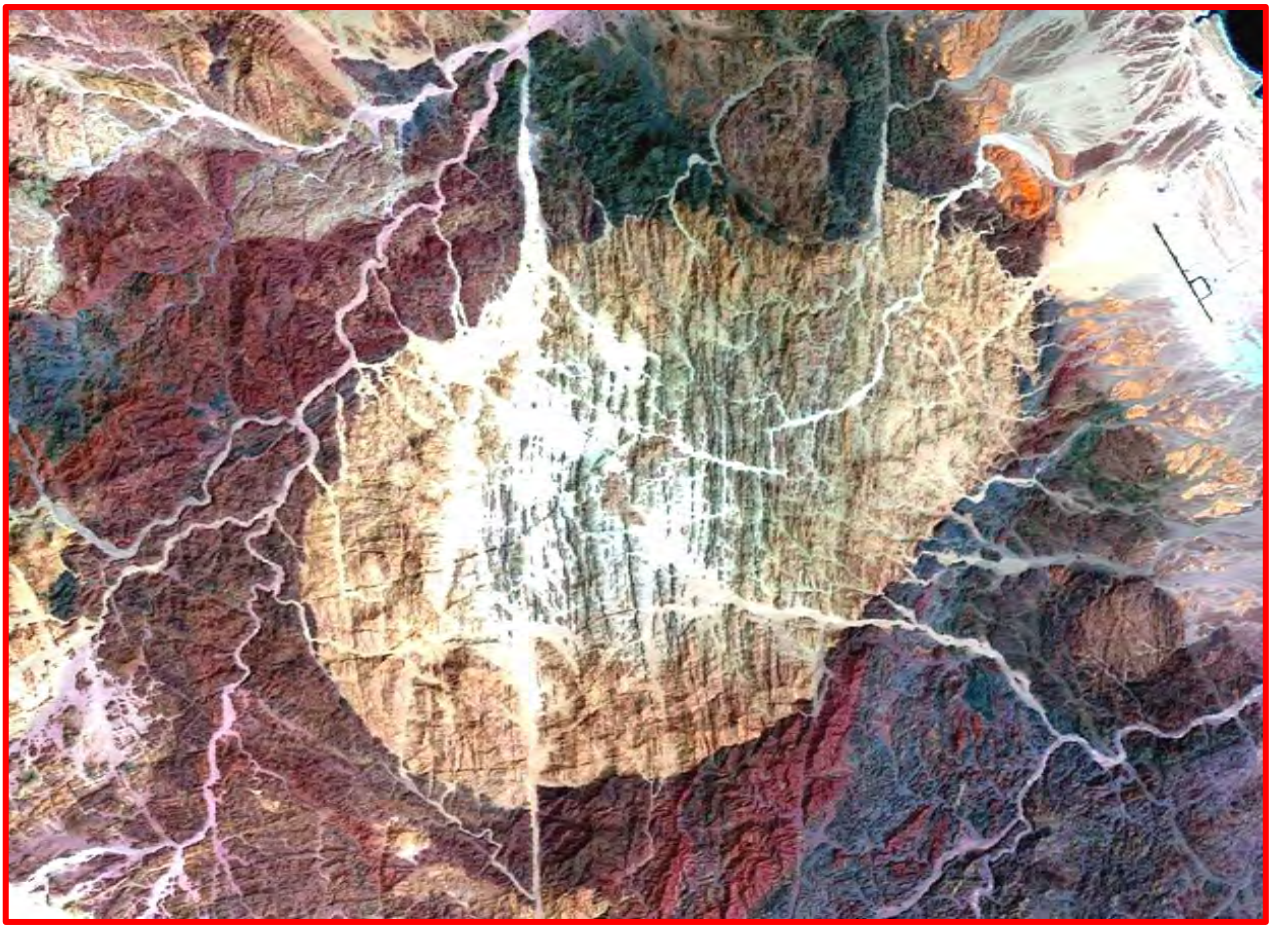
CAIRO UNIVERSITY
FACULTY OF SCIENCE
GEOLOGY DEPARTMENT

REMOTE SENSING (G-411)

Practical Course

Step by step tutorial



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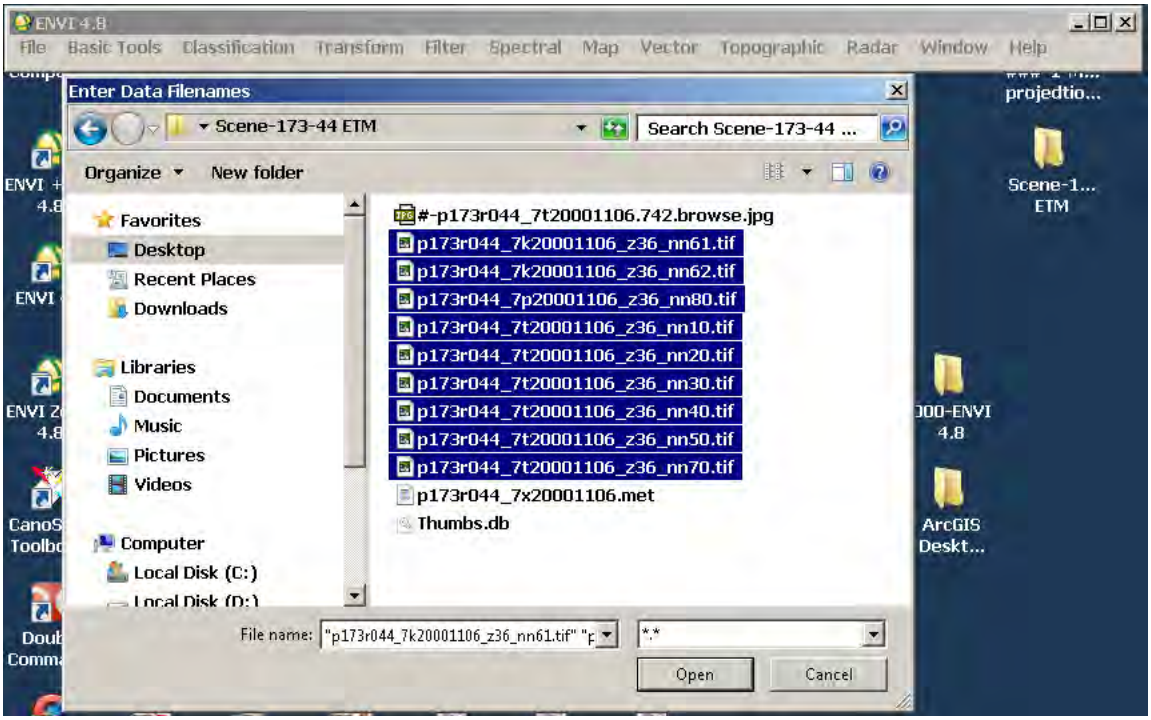
2018

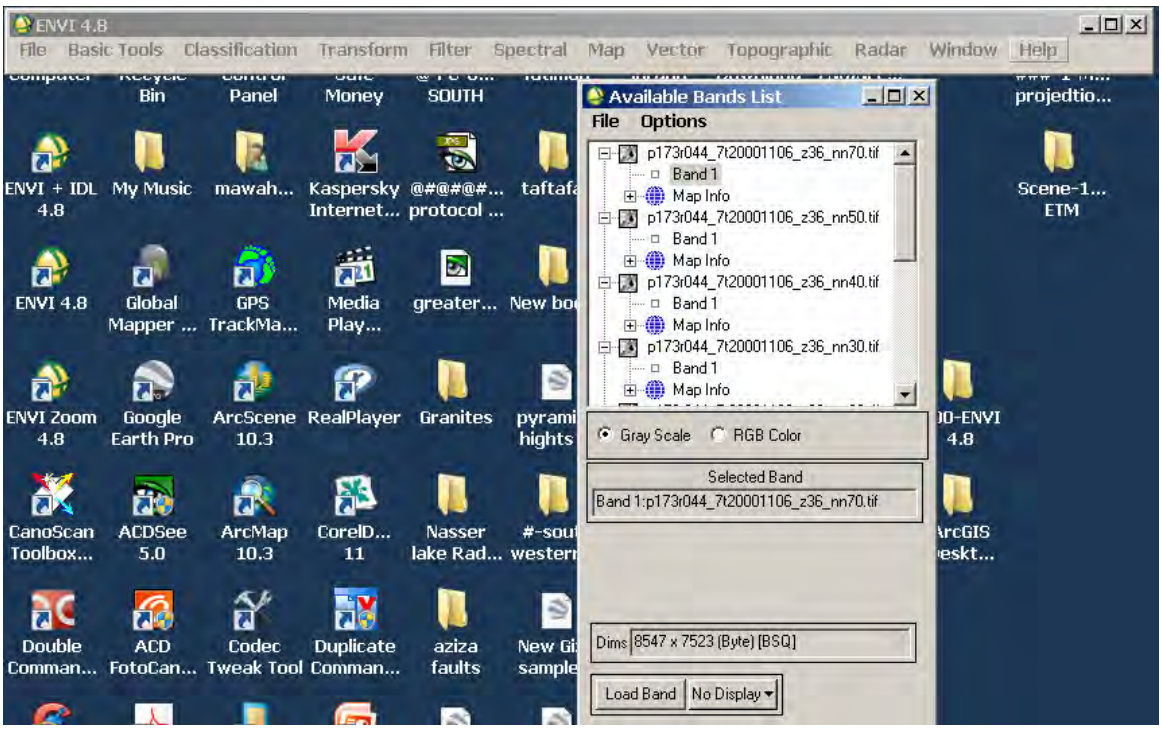
Contents

I- Working with ENVI

1- **Open the software.**
2- **From "File/open image file" open the files of the 7 bands of "Scene-173-44 ETM":**

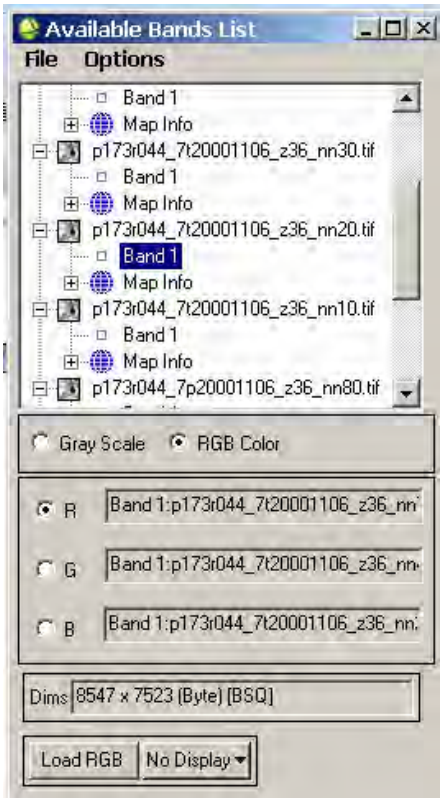


3- The pannel of the "Available band list" will be opened showing the list of the bands opened in the software.

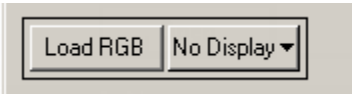


4- Activate the

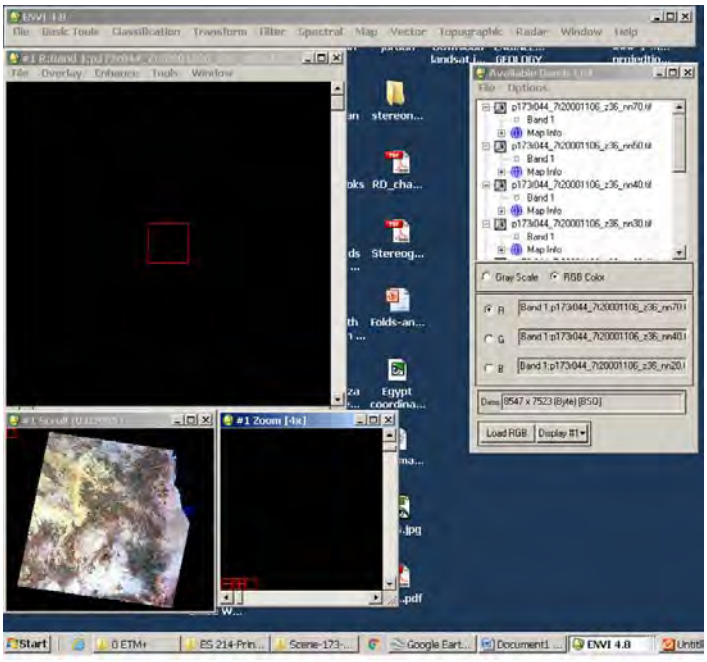
5- Select bands: the band combination
7 & 4 & 2 . where
Band 7 for R (red)
Band 4 for G (GREEN)
Band 2 for B (BLUE)



6- press “Load RGB”

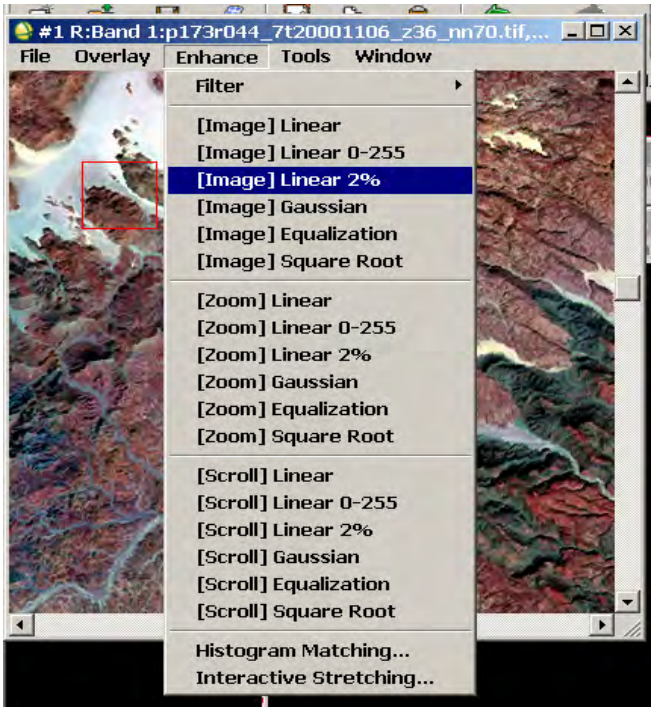


7- This will open three pannels.
The lower left one is the Scene image of band combination
7 / 4 / 2.
The other two bannels are two levels of zoom.
Pressing at any part in the scene in the lower left pannel will display the zoomed image of this part in the other two pannels.
Pressing at any point in the upper pannel will show a more zoom of the point in the lower right pannel.



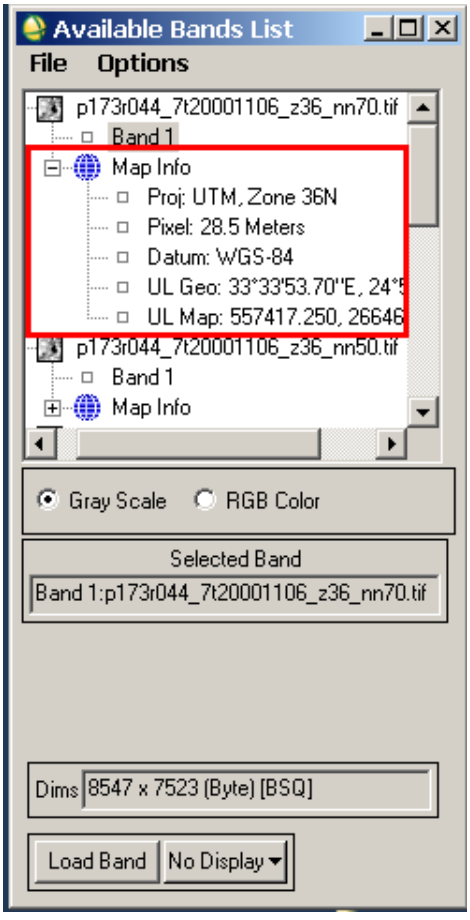
8- Try to Enhance the image by using “Enhance/[image] Linear 2%”.

9- Try other enhancment types.



10- Try other band combinations such as (3, 2, 1 natural color) or any other combination you want. You will find that the best one for geologic discrimination is 7,4,2 for R,G,B.

11- Notice: in the pannel of the “Available band list” Each band is associated with “Map Info” item, which contain the type of projection and datum, pixel resolition, and the coordinates of the upper left corner of the image in geographic and UTM coordinates.
To see these parameters, just press the + sign in front of the “Map Info” item.

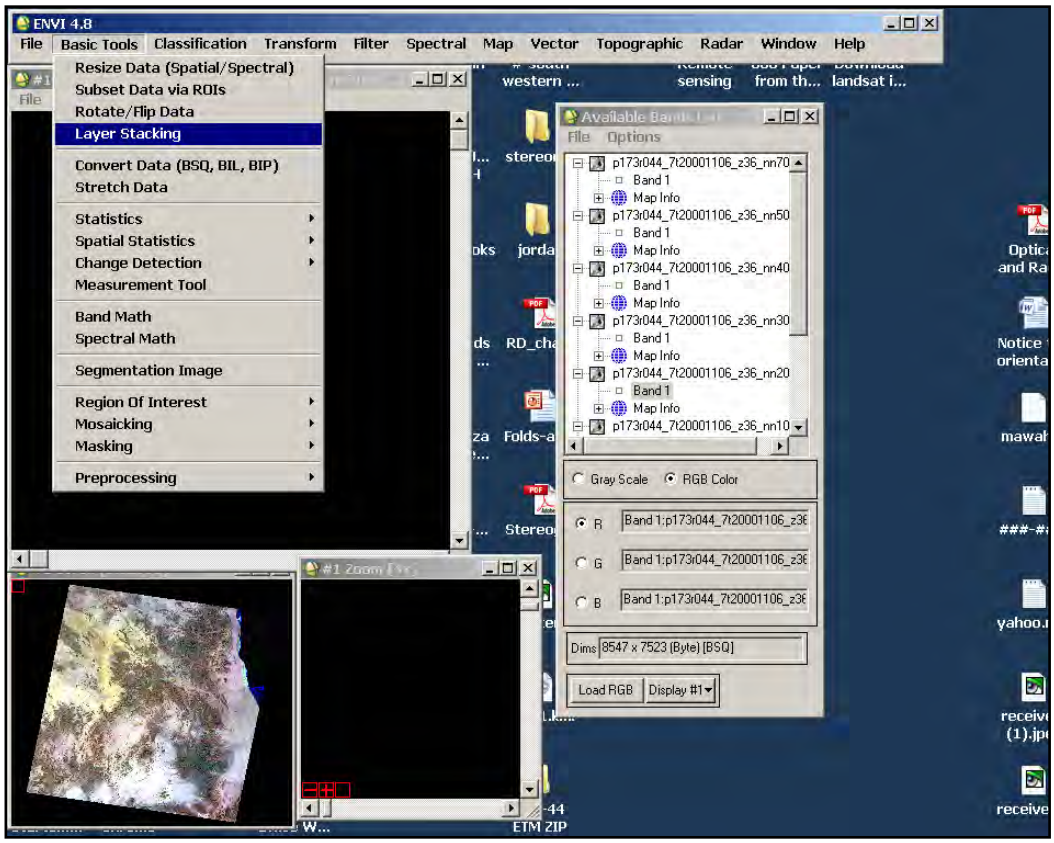


II- Layer Stacking (grouping all bands in one file)

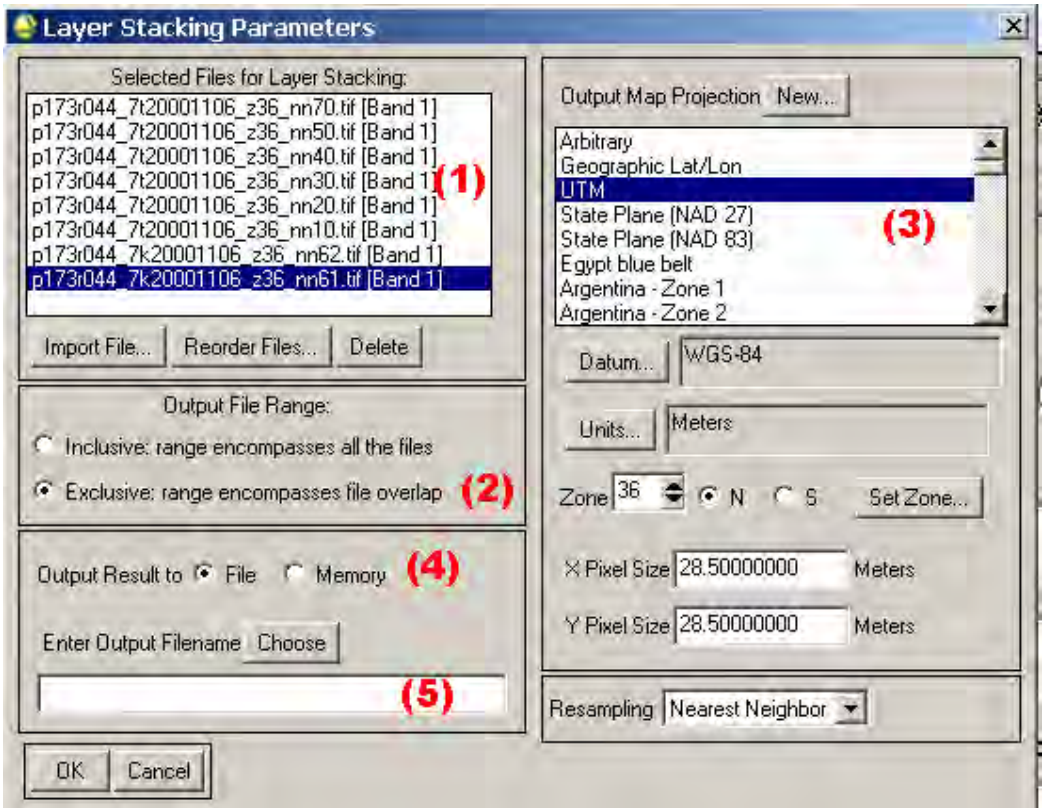
- The process of stacking is to group all bands in one file.
- You cannot form a band combination from files of different resolutions.
- If you try to form a band combination from bands (6, 5, 3), the software will not accept that, because the resolution of band 6 is 60 m and bands 3 & 5 are 30 m.
- To solve this problem you can make a **stack** file (grouping all bands in one file). During the process of stacking the software make all bands to be of the same resolution, and will raise the files of lower resolution to the higher resolution, but without any enhancement of details.
- Stacking bands (1,2,3,4,5,7,61,62) will produce a stack file containing all bands and the resolution of the thermal bands (61 and 62) will be 30m.
- After stacking, you can make any band combination including band (6).
- Use the bands of **"Scene-173-44 ETM"** given to you in the previous section.

The steps of making a stack file is as follows:

1- Open bands (1,2,3,4,5,7, 61, and 62) in Envi.
2- In the main menu of the program, go to **"Basic tools/ Layer stacking"**

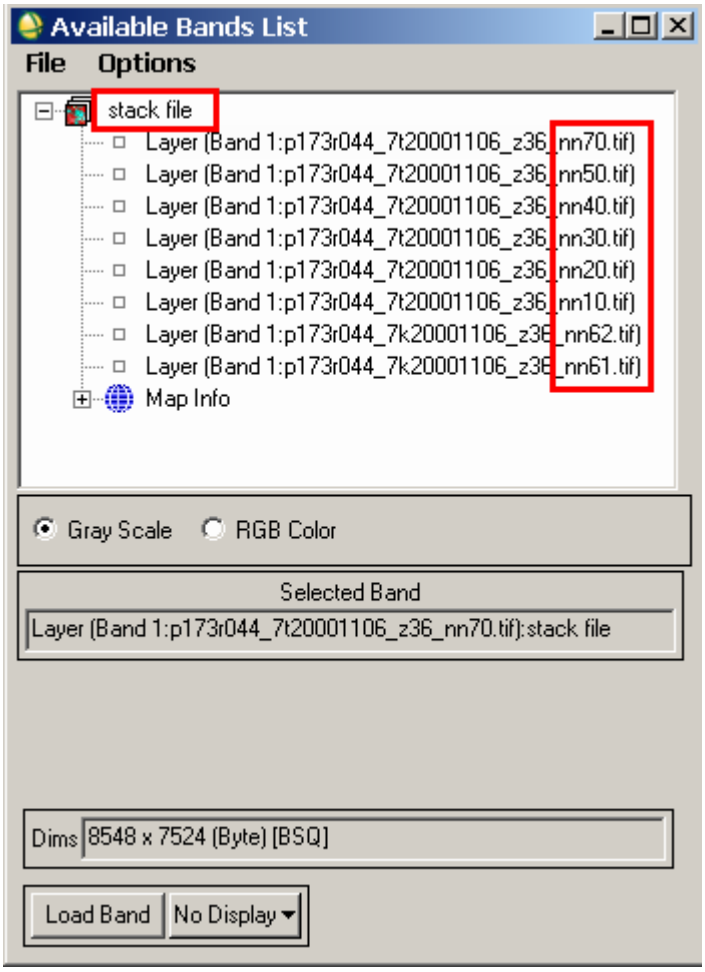


3- This will open the following dialog box.

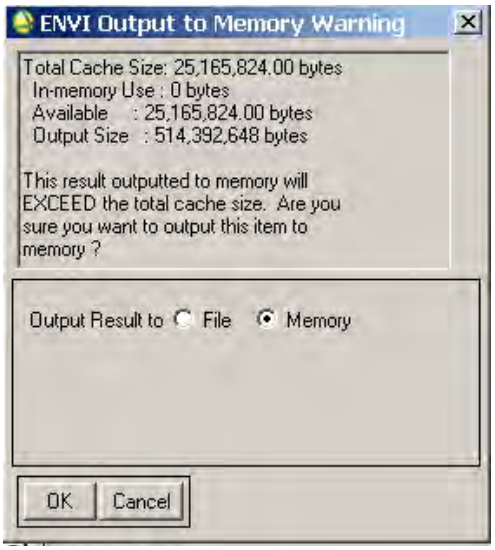


1- Press “Import file” . The list of the opened files in the “Available bands list” appears. Select the files to be stacked.
2- Select “Exclusive range …..”,
3- Check on the (coordinate system, Datum, Zone, and resolution) if they are correct. The scene given to you is of coordinate system (UTM), Datum (WGS84), Zone 36 N, resolution must be 28.5.
4- Choose if you want to save the resulte as a file directly, or get the results in the memory and you can save it later.
5- **If you choose to get the results in a file directly**, you had to give a file name and where to save the file and press “ok”. **The saved stack file will be in the format of “Envi standard”. This file type has no extension and could not be opened in any software except Envi.**

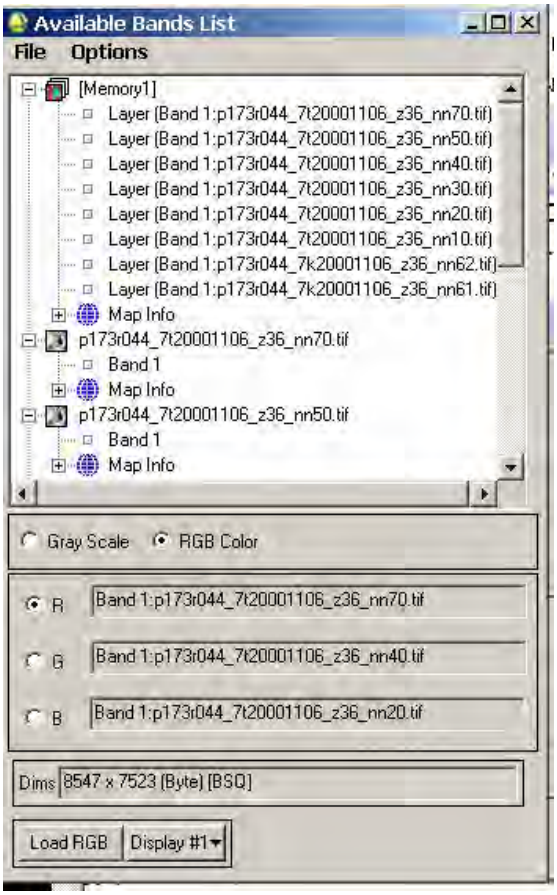
Open the saved stack file in the “Available bands list”. You will find that the files chosen to be stacked are represented as layers in the stack file (see the following figure). **It is important to note that, the name of each layer in the stack includes the name and number of the original file intered into the stack.**



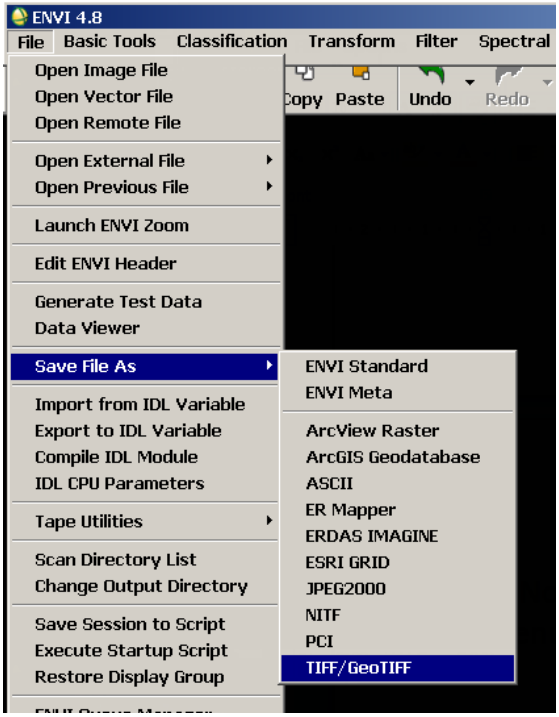
4- **<u>If you Choose to get the results in the memory</u>**, press “ok”. The following box apears. Select “memory” again and press “ok”.



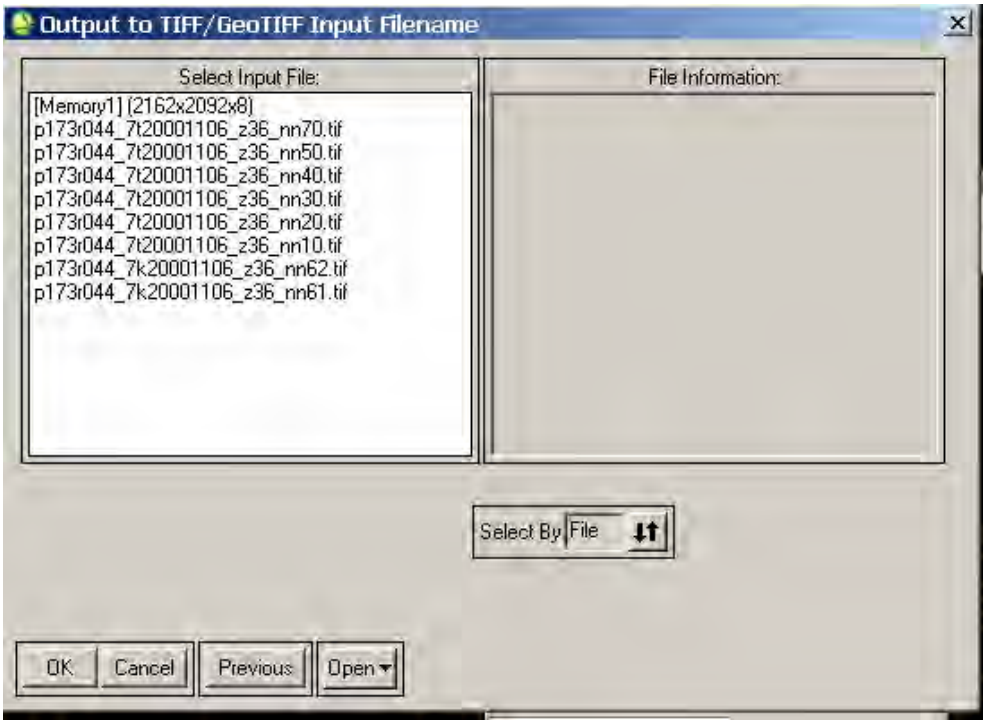
5-The stack file will appear in the “Available band list” dialog box as a memory layer containing all bands.



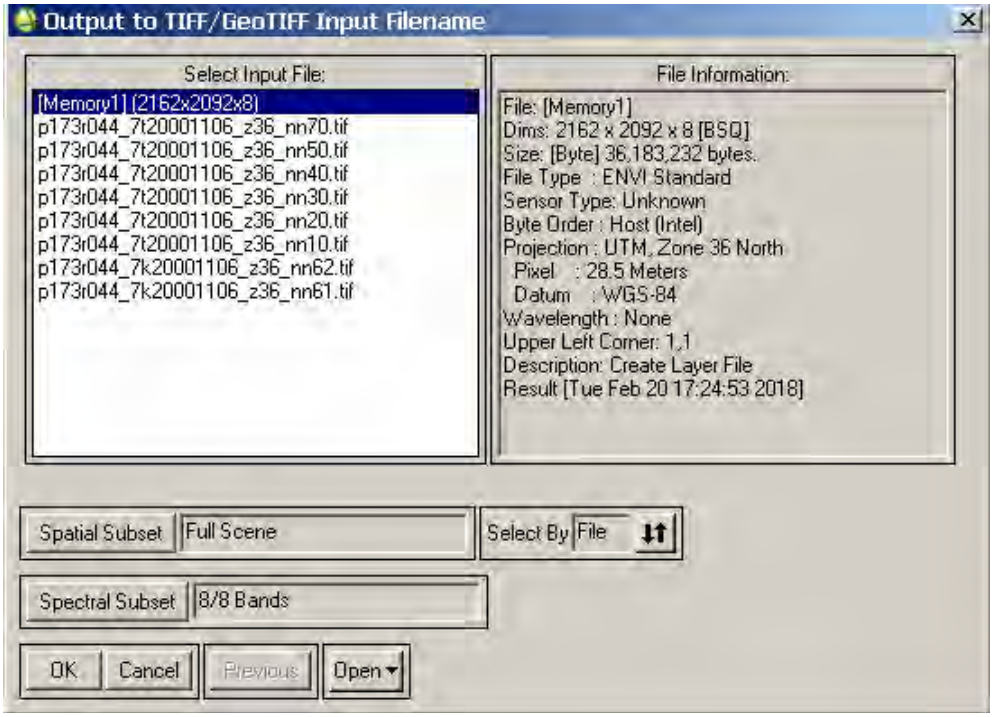
6- Now you can save the memory layer of the stack file. Go to the **main menu** of the sotware, point to “save file as/ Tiff-Geotiff”.



7- The following box appears. Select the memory layer as input file .



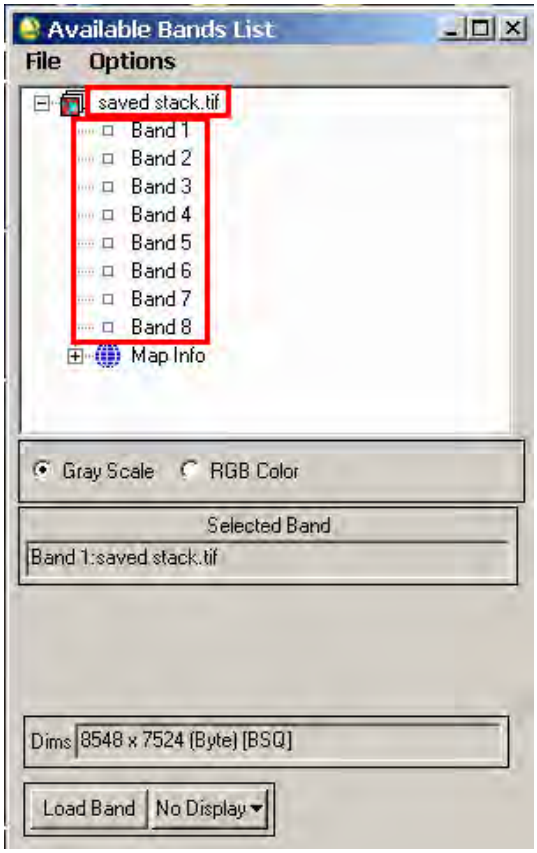
When you select the input file an additional part will appear in the dialog box concerned with making a subset of the scene. If you want to make a subset use the “spatial subset” icon. If not press “ok”.



8- The following box appears. choose the file name and location to save the stack file.

9-Open the saved file in the “Available bands list”.

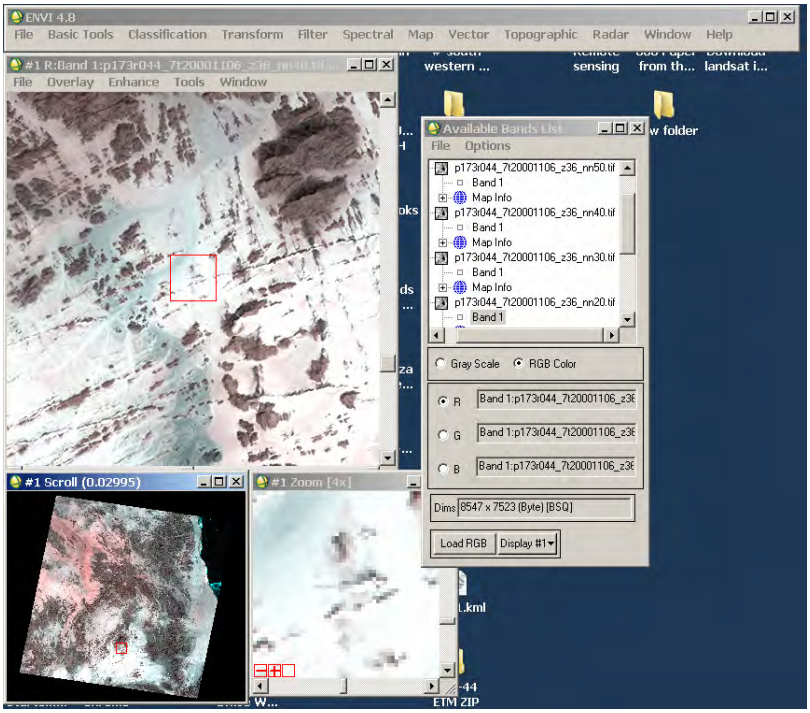
It is important to note that, the name of each layer in the stack file does not include the name and number of the original files intered into the stack. The bands ar numbered in sequence does not related to the original band number. So, to use these bands in band combination, you had to put in mined the original sequence of bands intered in the stack (band numbers).



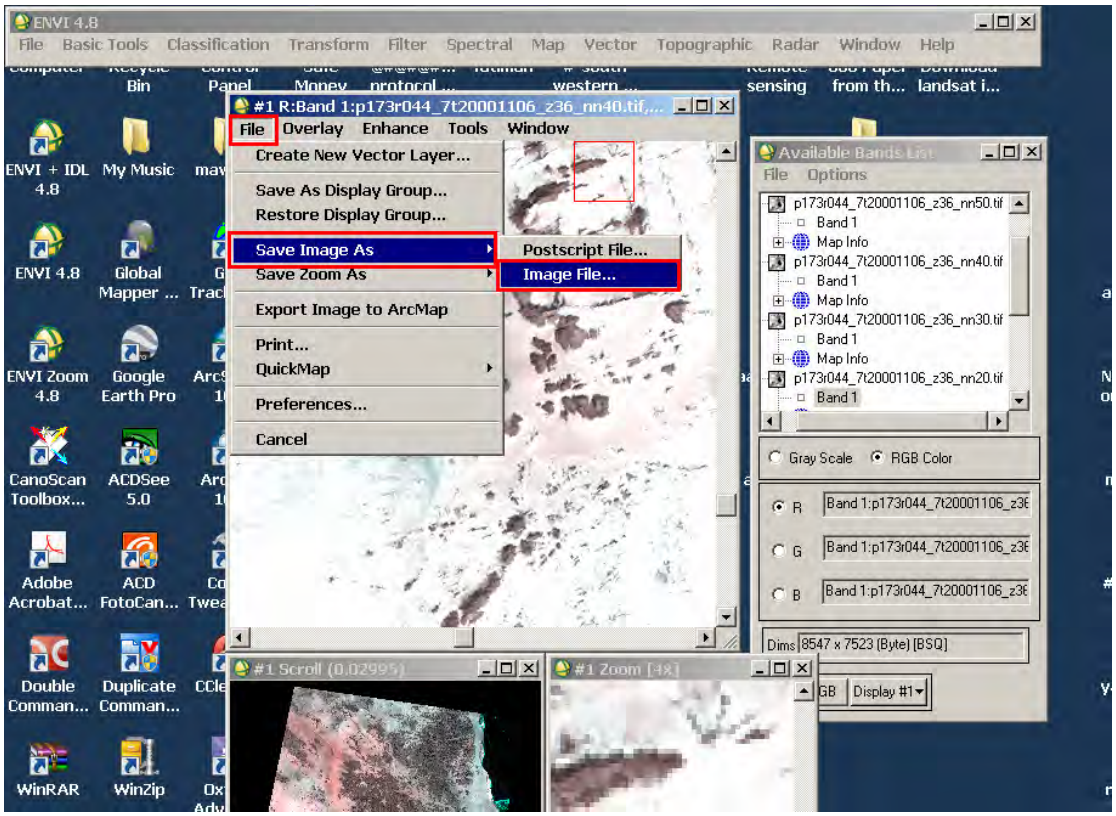
III- Subset (saving a part of the scene)

I- Subsetting an image loaded in the display:

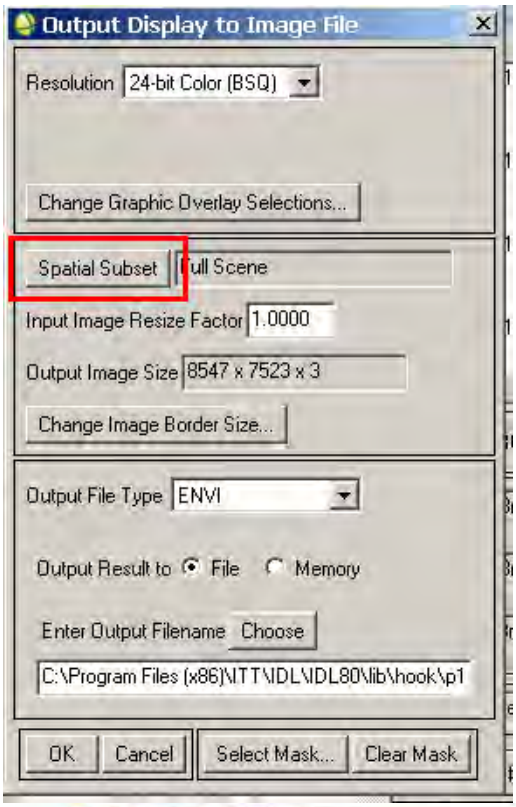
1- Construct a band combination (7,4,2) from the provided scene "Scene-173-44 ETM".



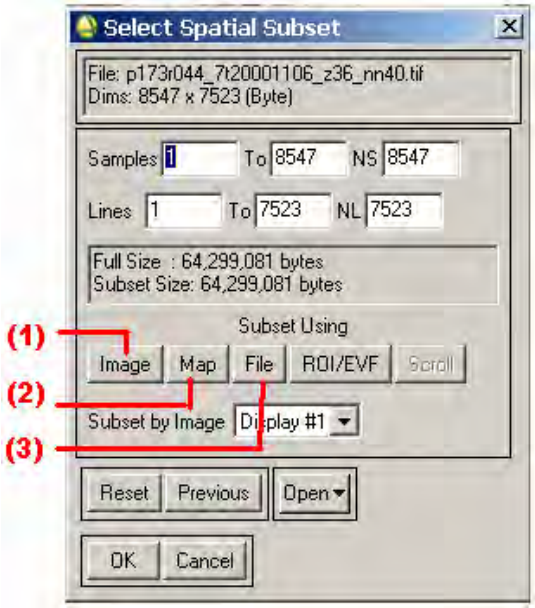
2- In the zoom window, Point to "File/save image as/image file".



3- The following dialog box appears:



4- Press the “Spatial subset” icon.
The following dialog box appears:

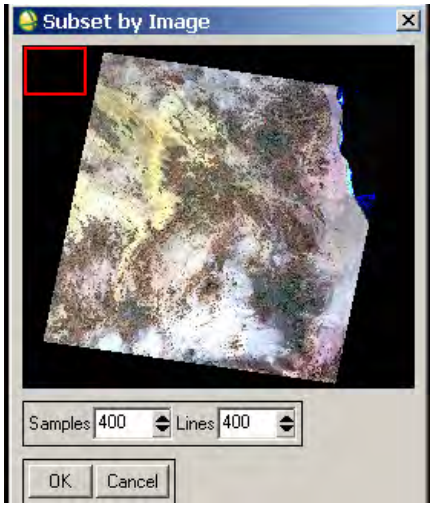


5- Three methods for subset can be used:

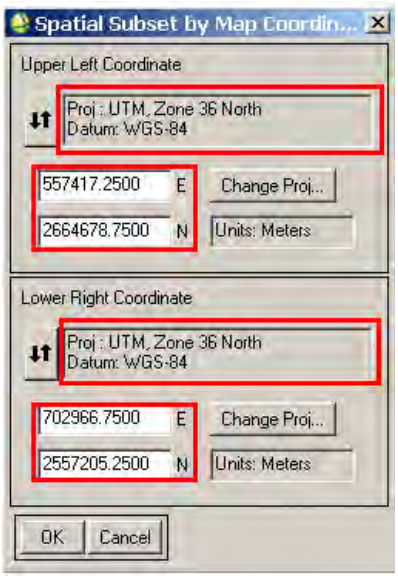
1- <u>By Image.</u>
2- <u>By Map.</u>
3- <u>By file</u>.

1- <u>Subset By Image</u>:

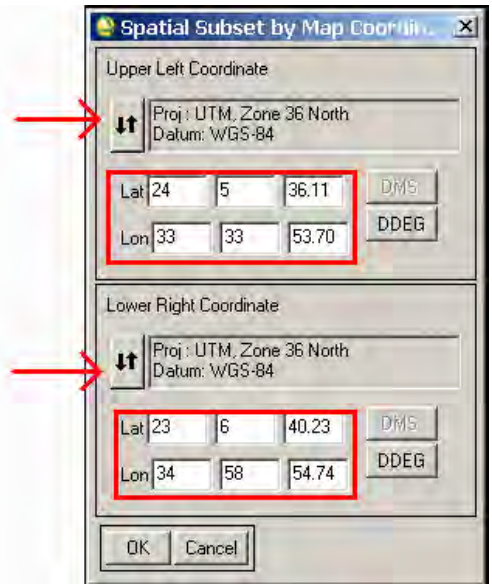
- press “image”, the subset by image box appears, with a red rectangle inside. Drag the rectangle from its corners to fit the area you want as a subset.
- Press “ok” to return to the previous box, then press “ok” to return to the first box.
- In the first box define the file format as Tiff, and the output result as file, and define the output file name and the loation to save. Then press “ok”. The subset will be saved.



2- Subset By Map:



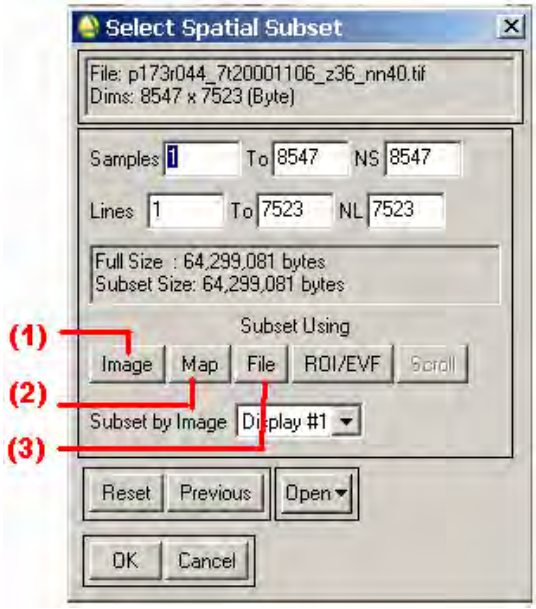
- To use this method you must have the coordinate of the upper left and lower right corners of the subset area.
- Press “Map”, the subset by Map box appears.
- In this box the coordinate system is defined in the upper rectangle, and the coordinates of the Upper left and Lower right corner of the scene are given.
- These coordinates are given in UTM system.
- If you have the coordinates if the subset area in UTM, insert the values of the upper left and lower right corners directly in their respective rectangles.



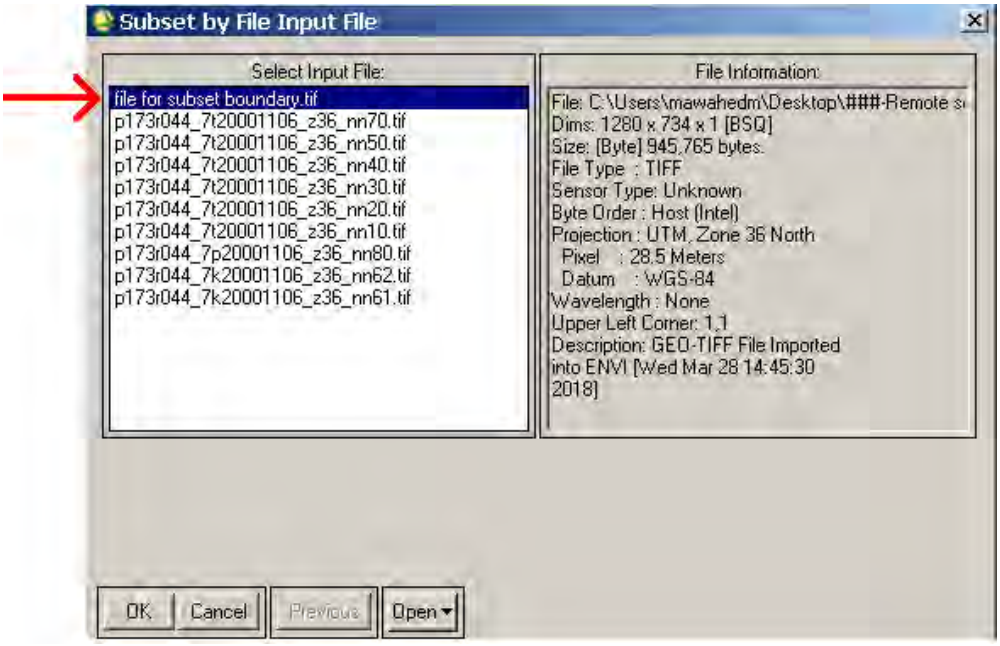
- If you have the coordinates in geographic system as latitudes and longitude s, you must press the icon to change the coordinate fields to Lat and long, then insert their values .
- Press “ok” to return to the previous box, then press “ok” to return to the first box.
- In the first box define the file format as Tiff, and the output result as file, and define the output file name and the loation to save. Then press “ok”. The subset will be saved.

3- Subset By file:

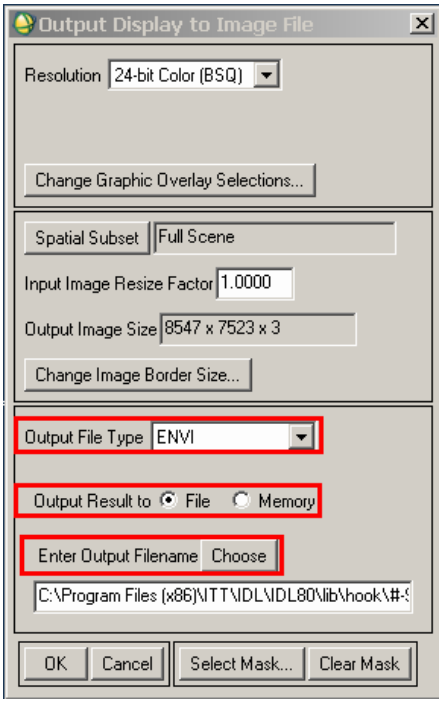
- If you have an image or map of the area you want to subset, you can use this file to define the boundaries of this area. You can use the file attached in your data “file for subset boundary.tif”. This file is a black and white image for a certain area within the scene.
- This file must be opened in Envi before using it in the subset process.
- Press “File”, the subset by File box appears.

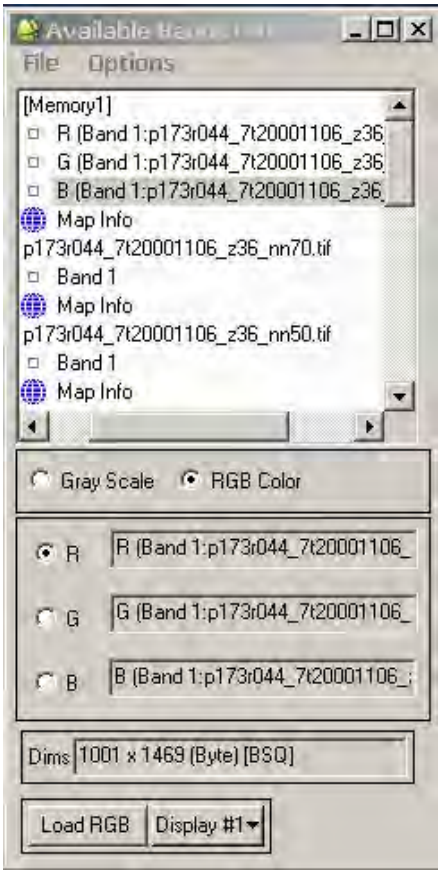


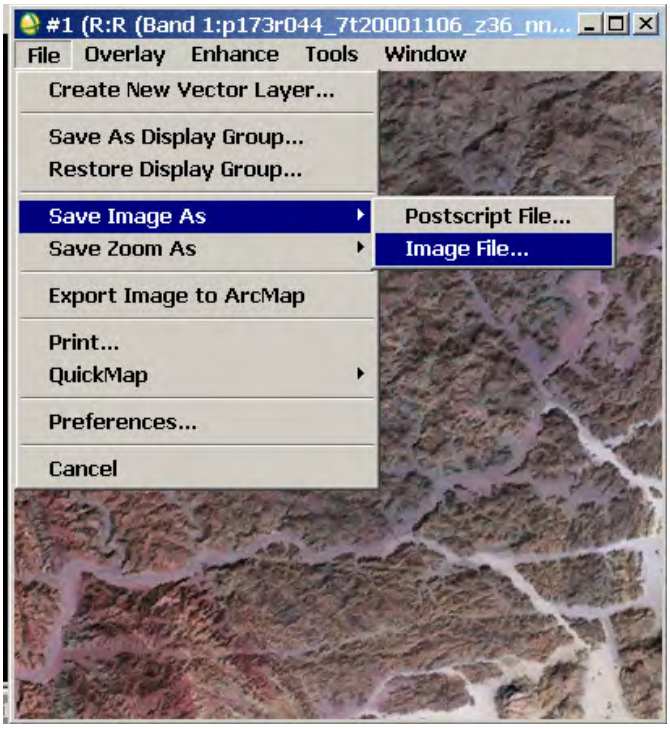
- Press on the file you want to use for subsetting.



- Press “ok” to return to the previous box, then press “ok” to return to the first box.
- In the first box define
  1- the file format in the “output file type” box as Tiff .
  2- the output result as “file”.
  3- Choose the output file name and the loation where to save the file. Then press “ok”. The subset will be saved in the spicified location.
- You can save the file into memory to see the resulted subset. The file will be opened in the “available bands list” box as memory file. To see the results load the file in a new display. You can save the file in the regular way .

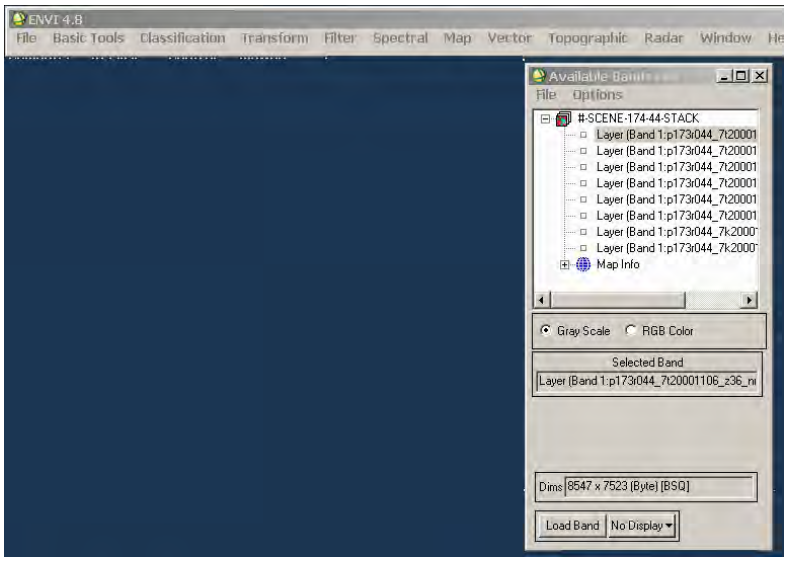




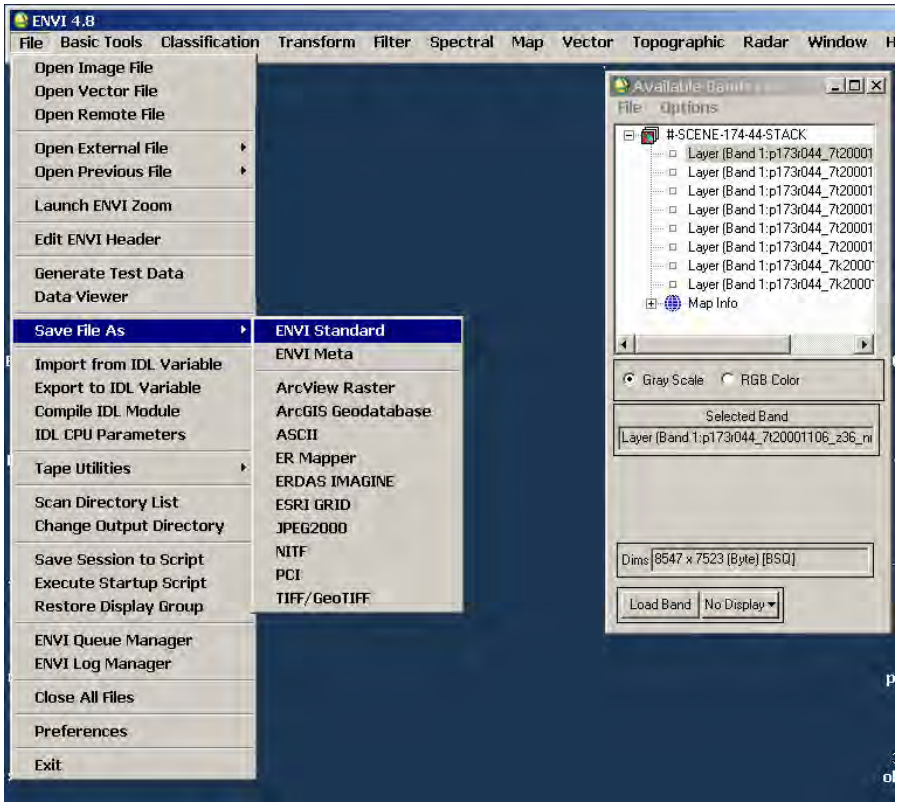


II- Subsetting a Stack file:

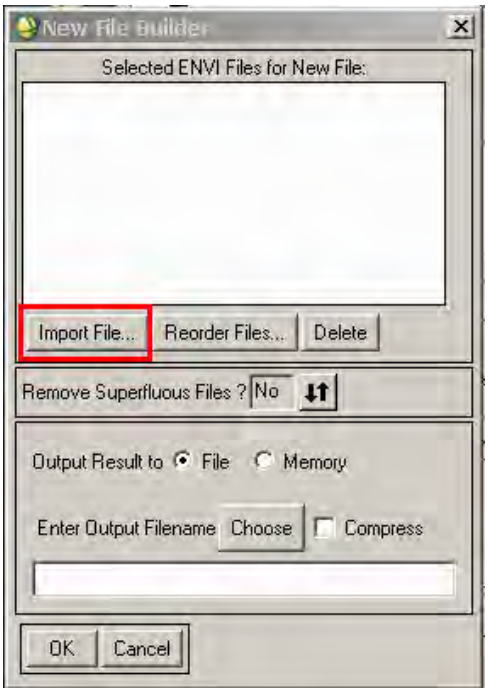
1- Use the stack file you produced in the previous section.



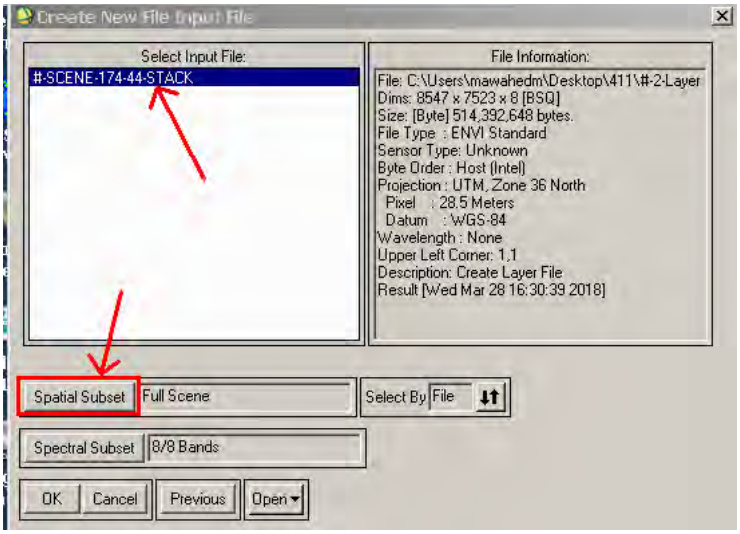
2- In the main menu of the program, press “file/save file as/Envi standard”.



3- The “New file dialog” box appears. Press on import file.

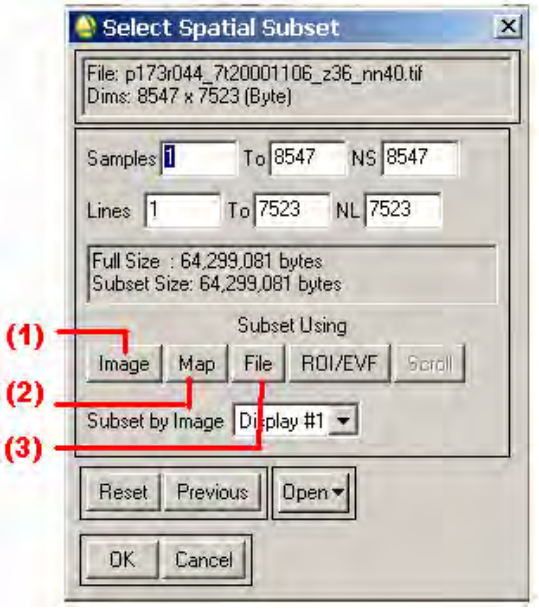


4- The “create new file input file” dialog box appears. Highlight the stack file. Press on the “spatial subset” button.



5- The “select spatial subset” box appears. You can make the subset as described before (by image, map, or file).

6- Save the file as described before. Or save to memory then save into file as described before.



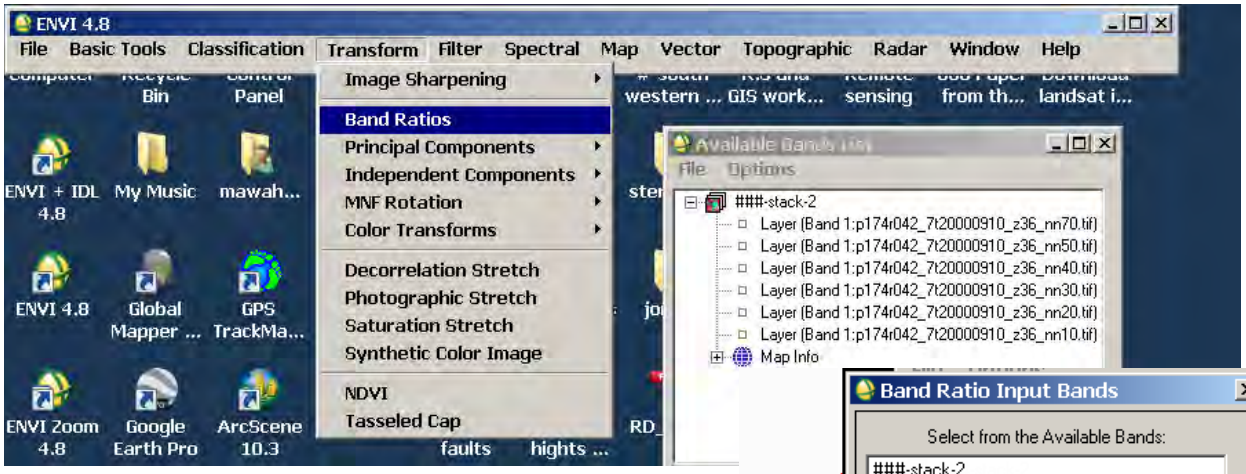
IV- Band Ratios

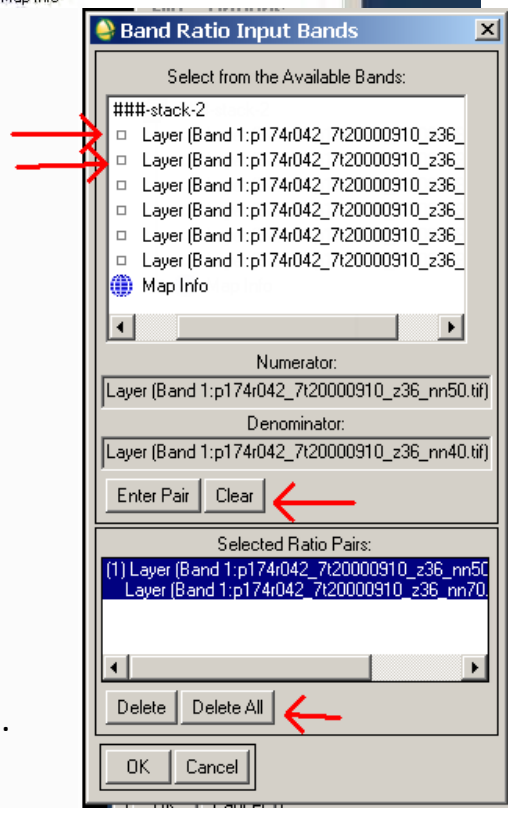
The Ratios to be applied on the attached files "stack-1 and attack-2" are:

1- **Start first with 7,4,2 on the file stack-1**
2- **Form the following ratios and compare with 7,4,2**
   - **A- 5/7 - 5/4 - 3/1 for R,G,B**
   - **B- 5/7 - 4/5 - 3/1 for R,G,B**
3- **Repeat the same process on the file stack-2**

Procedure:

1- Open the stack file in ENVI.
2- Form the band combination 7,4,2 and save the result as tiff file.
3- From the main menu of ENVI go to:
   Transform / band ratio

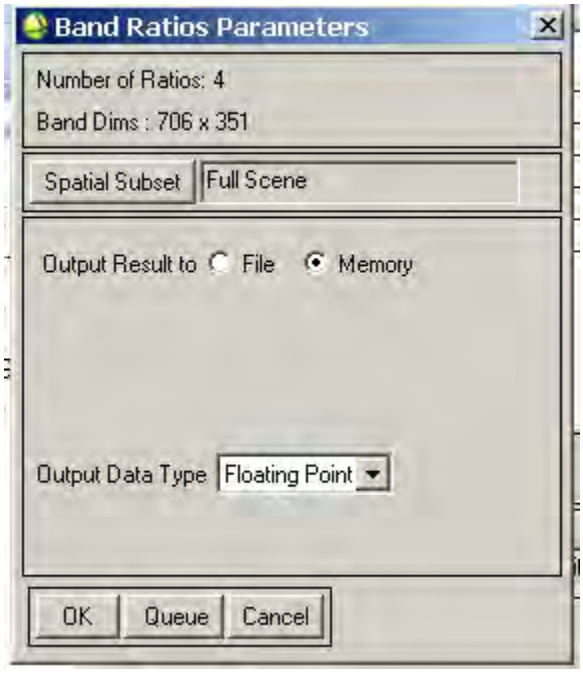




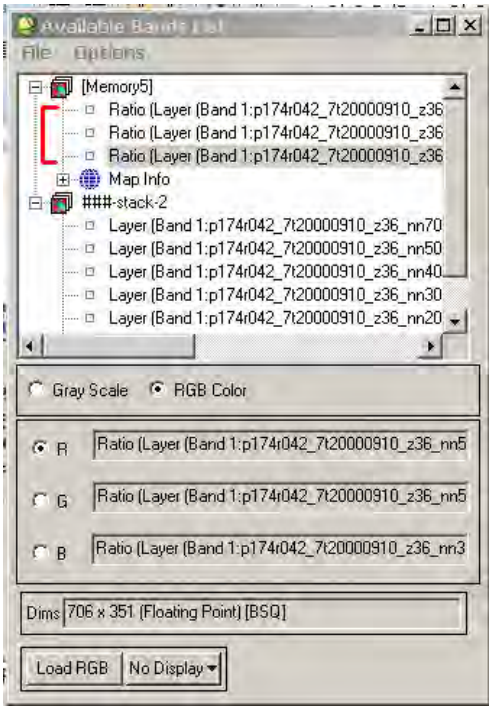
4- The "band ratio" box will be opened:
   To inter 5/7 ratio
   Press on band 5.This will inter this band in the numerator rectangle.
   Press on band 7.This will inter this band in the denominator rectangle.
   Press "inter pair" to inter the pair in the "Selected ratio pair field".
   Repeat the process with other ratios 5/4 and 3/1.
5- If you want to remove the ratio before entering it, use the button "clear".
6- If you want to remove a ratio from the "Selected ratio pair field", use the button "delete".

7- If you want to delete all entered data use “clears all”.

8- Press “ok”. The following box appears; choose memory and press “ok”.



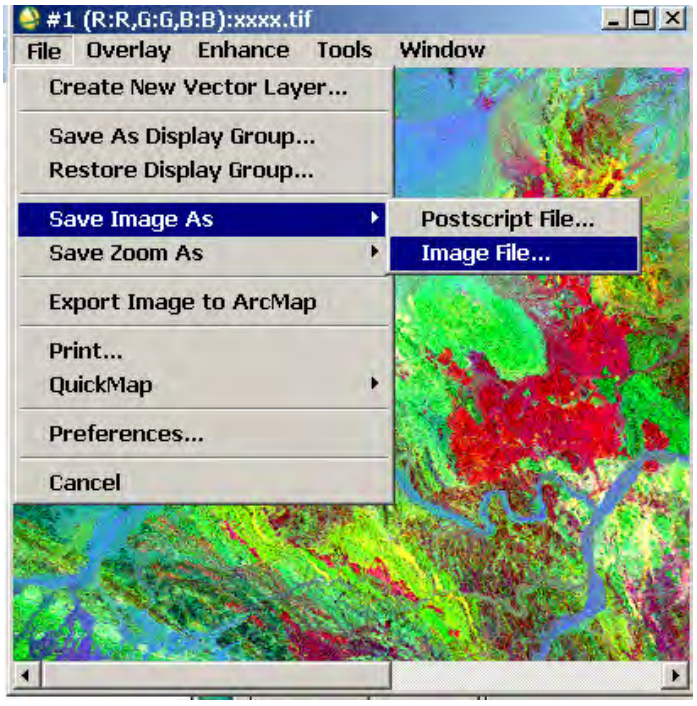
9- A memory layer is created in the “available band list” box, containing three bands representing the three ratios used.



10- Use the three layers for RGB and load the image.

11- Then save the result as tiff file from the image zoom window.

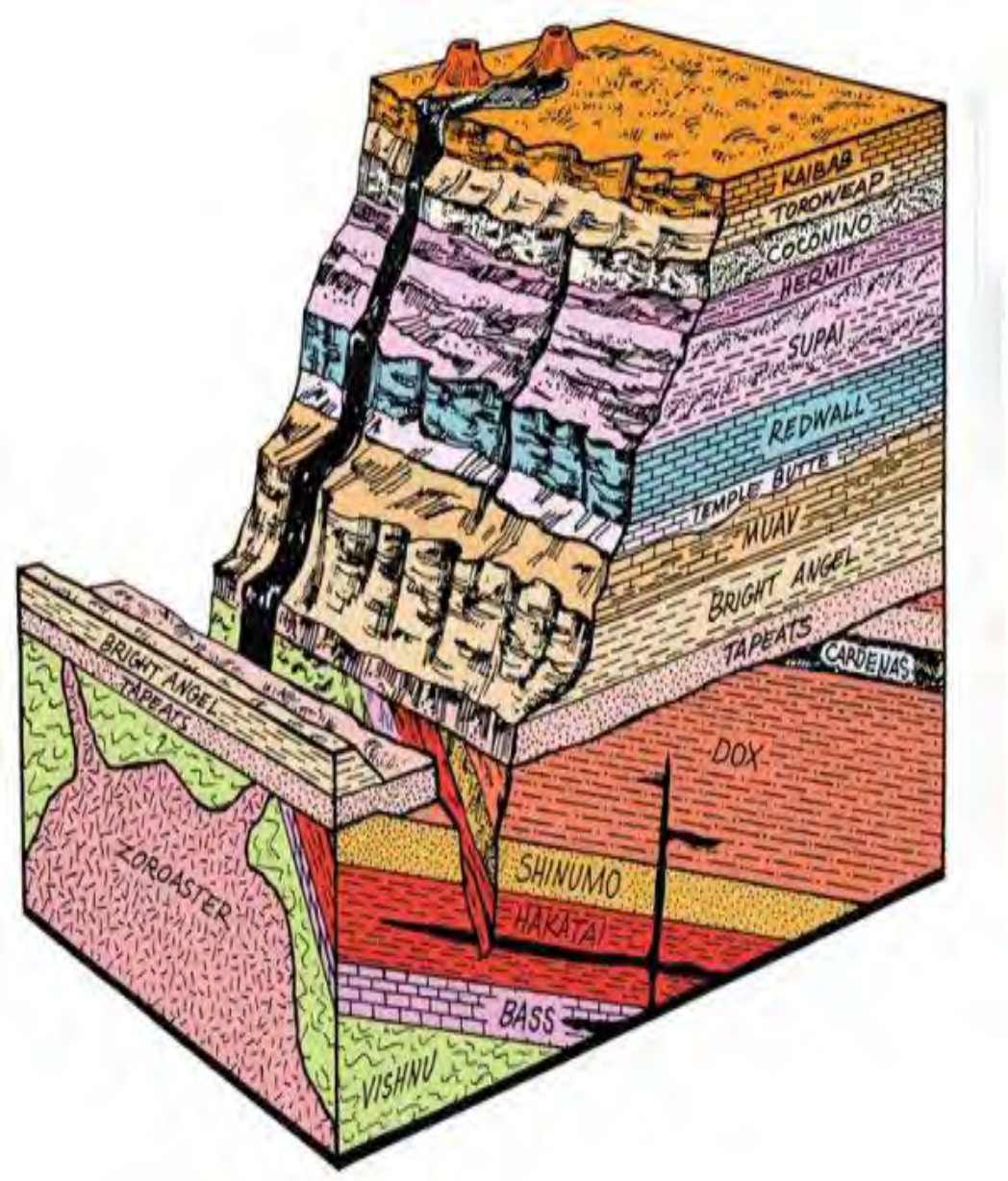
12- Compare the results of band ratios with the previously saved 7,4,2 file to see the advantage of the band ratio processing.



V- Geologic interpretation

Interpretation of dipping beds, folds, faults and lithologic contacts

Horizontal sedimentary bedding



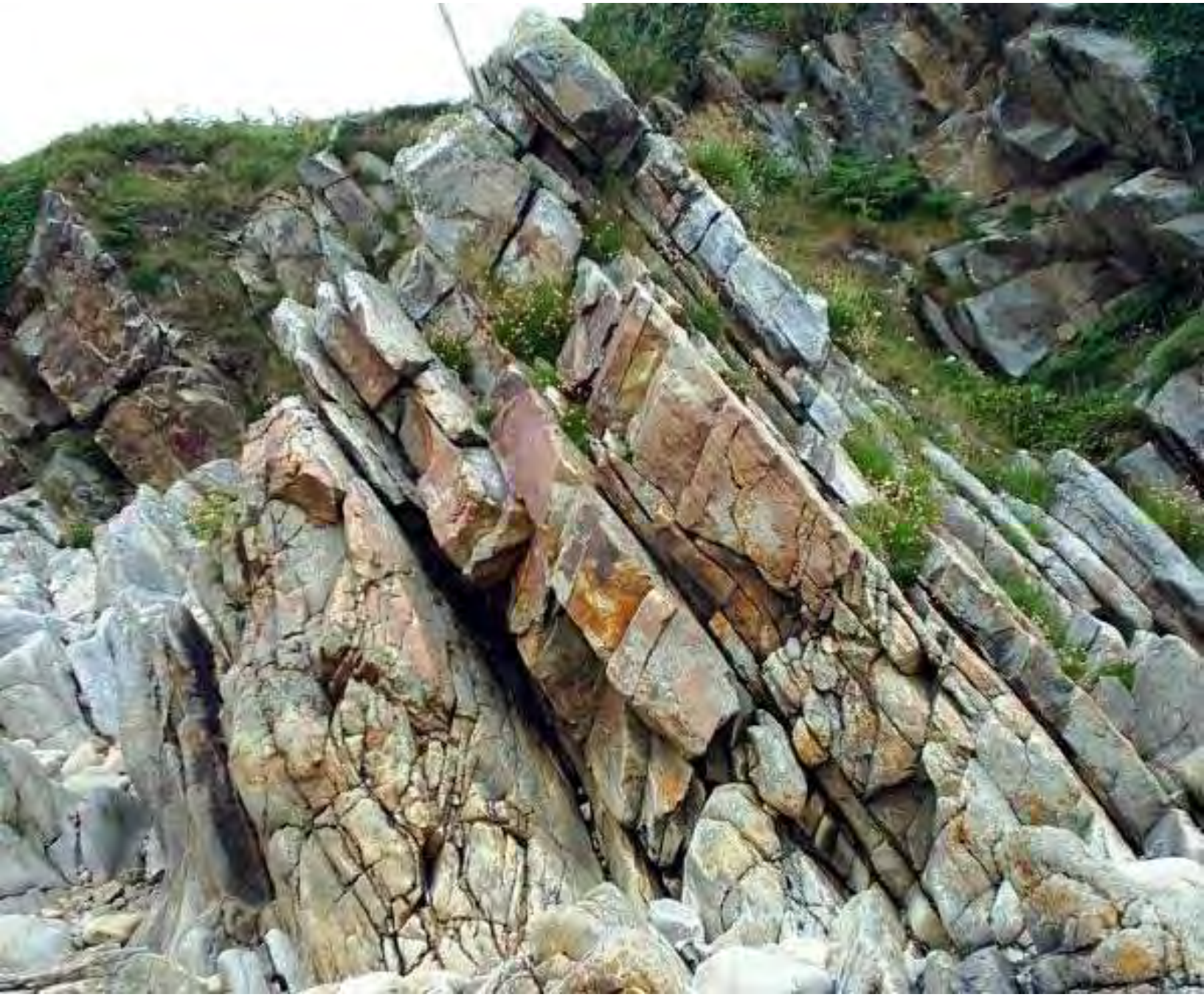
The effect of weathering on the outcrop pattern of beds (map view) Notice the effect of erosion on the outcrop of beds (V shapes)

Oblique aerial photograph of horizontal layers
Notice the V shapes in bedding along the small valleys

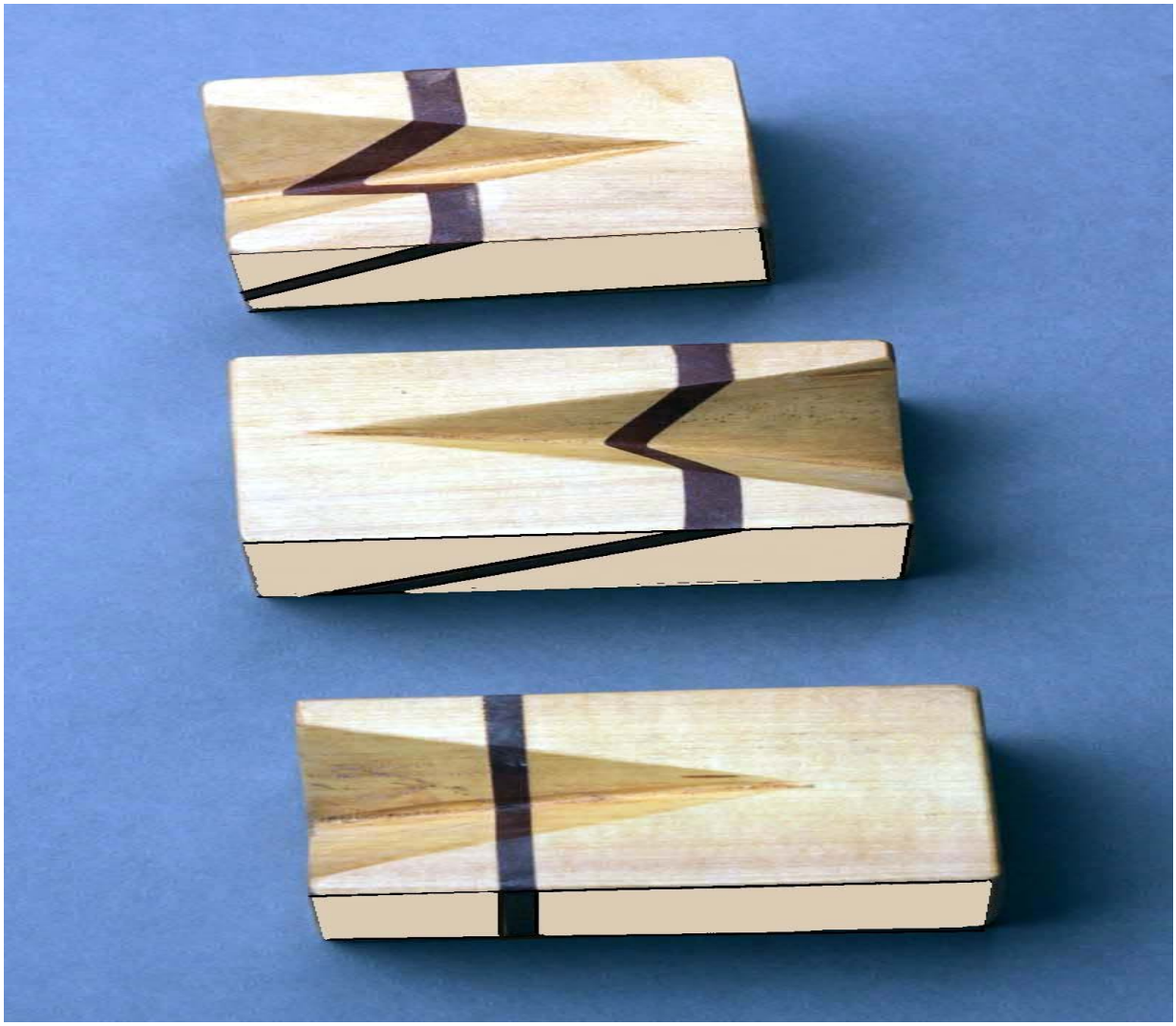
Google earth satellite image of horizontal layering
Notice the river and its deep erosion in the beds

Google earth satellite image of horizontal layering . Zoom on part of the previous photo . Notice the V shapes in bedding across valleys in different parts of the image. This detailed Outcrop pattern can only be seen at very high resolution images.

Sedimentary layers dipping at high angle



Dipping sedimentary layers



V-shape Rule

The blocks explain the effect of topography on the map view of beds. V shapes are formed
in the bedding planes across valleys (in horizontal, dipping, and vertical beds). In general, On the map view, the V shape formed in the outcrops of dipping beds across valleys points towards the dip of beds. So, this feature can be used in satellite images to determine the direction of dip of dipping beds.

Note

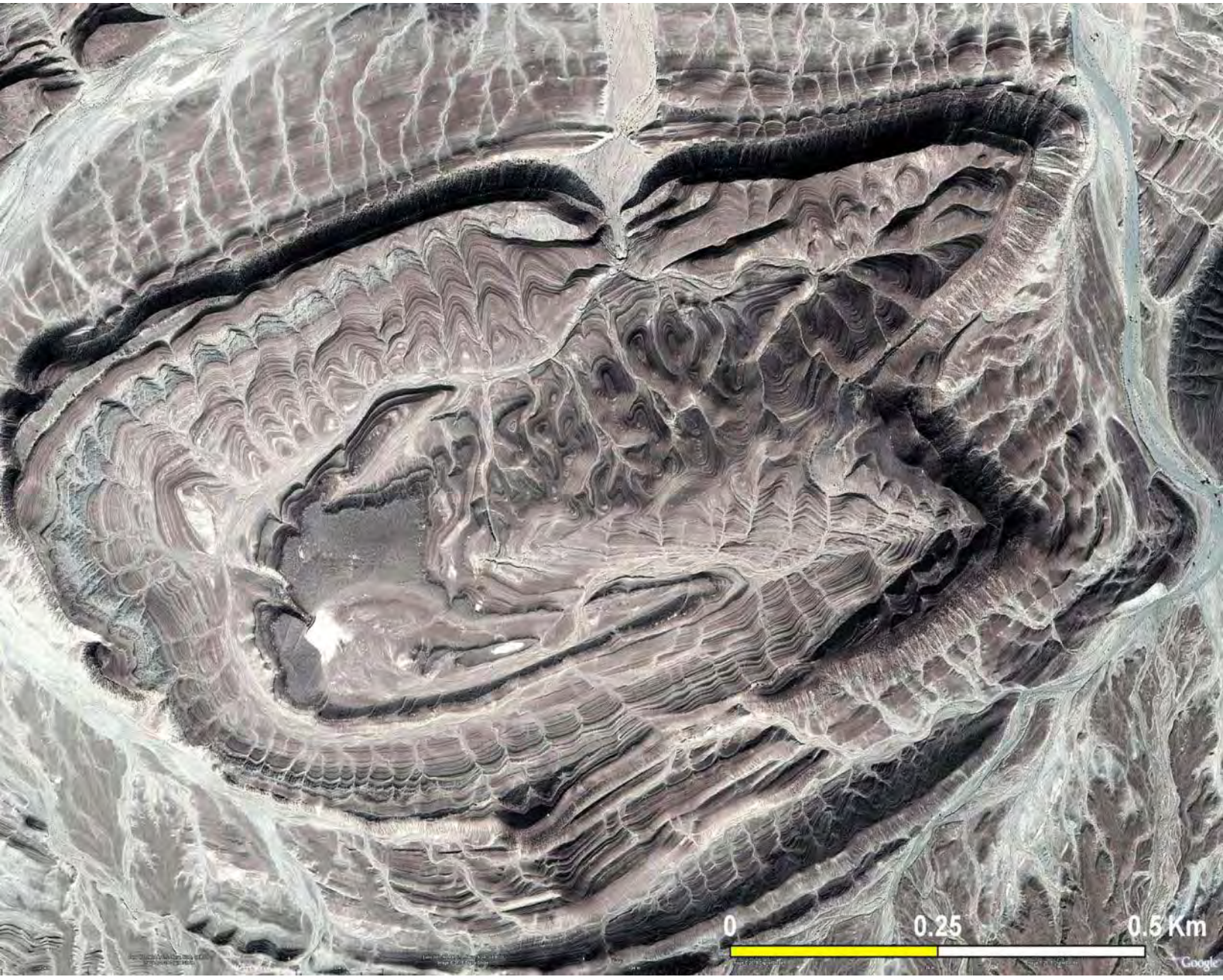
- **All the following satellite image are extracted from Google Earth at different resolution.**
- **The scale is drawn on each image.**
- **These images are in natural color 3,2,1 for R,G,B.**

Dipping beds

Cenozoic sedimentary succession, Pakistan. Try to see the satellite image as a 3D view. Based on the V shape rule, the beds are dipping inward defining a synclinal fold.

Satellite image of Cenozoic sedimentary rocks, Iran, folded in a complex pattern. Notice, the V shapes in bedding at the lower left side of the image.

Cenozoic folded salt beds, Iran.
Notice, the dip of beds at the lower part of the satellite image

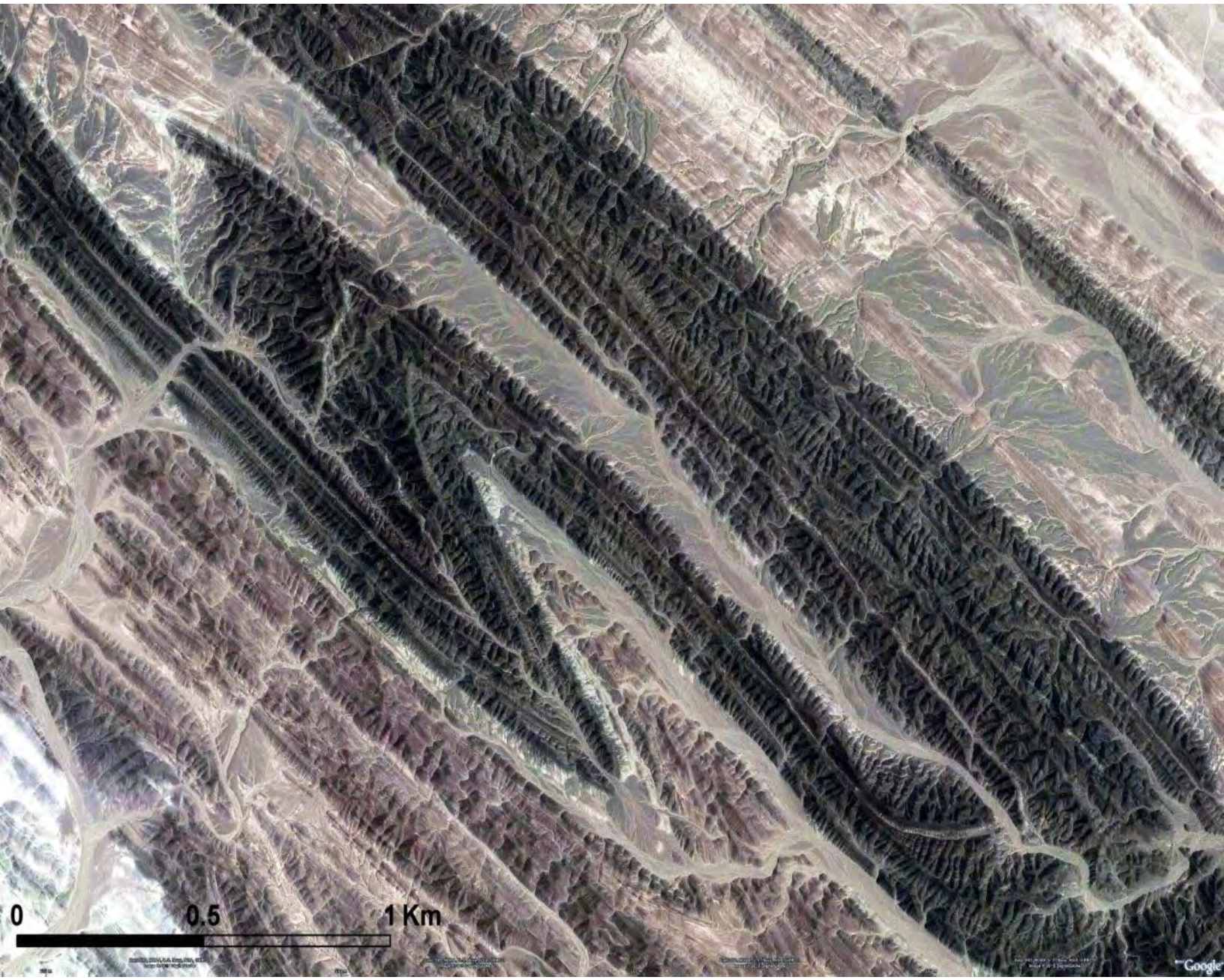


Complex folding in Cenozoic sedimentary rocks, Pakistan. Notice, the V shapes in bedding inside the structure, indicating a basin structure.

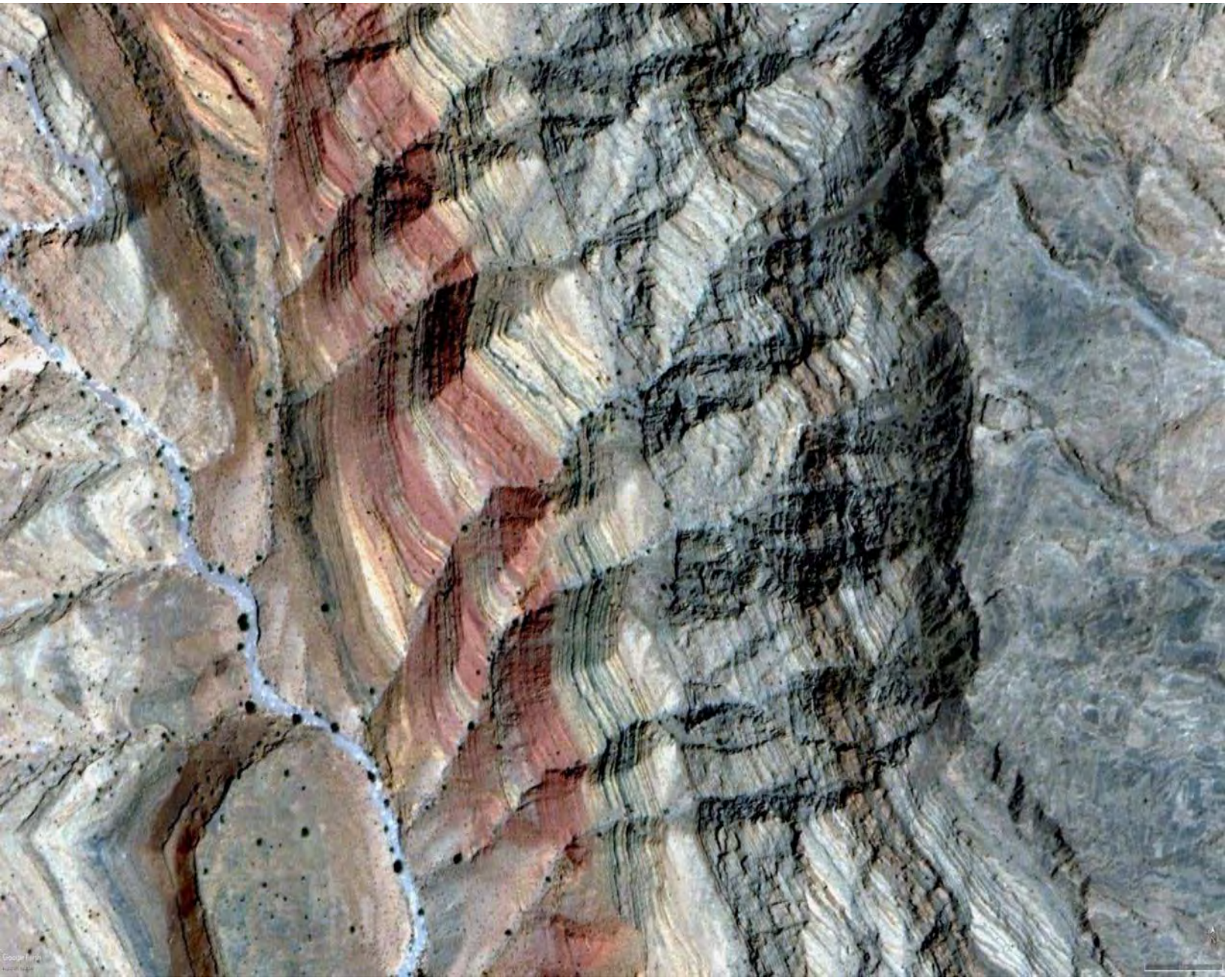
Lithologic contacts

Cenozoic Sedimentary rocks, Iran. Notice, The variation in tone and color between the different units. The contacts inbetween can be easily traced.

Satellite image of folded sedimentary layers intruded by granite. Notice the sharp contact inbetween. Jurassic rocks, Iran.

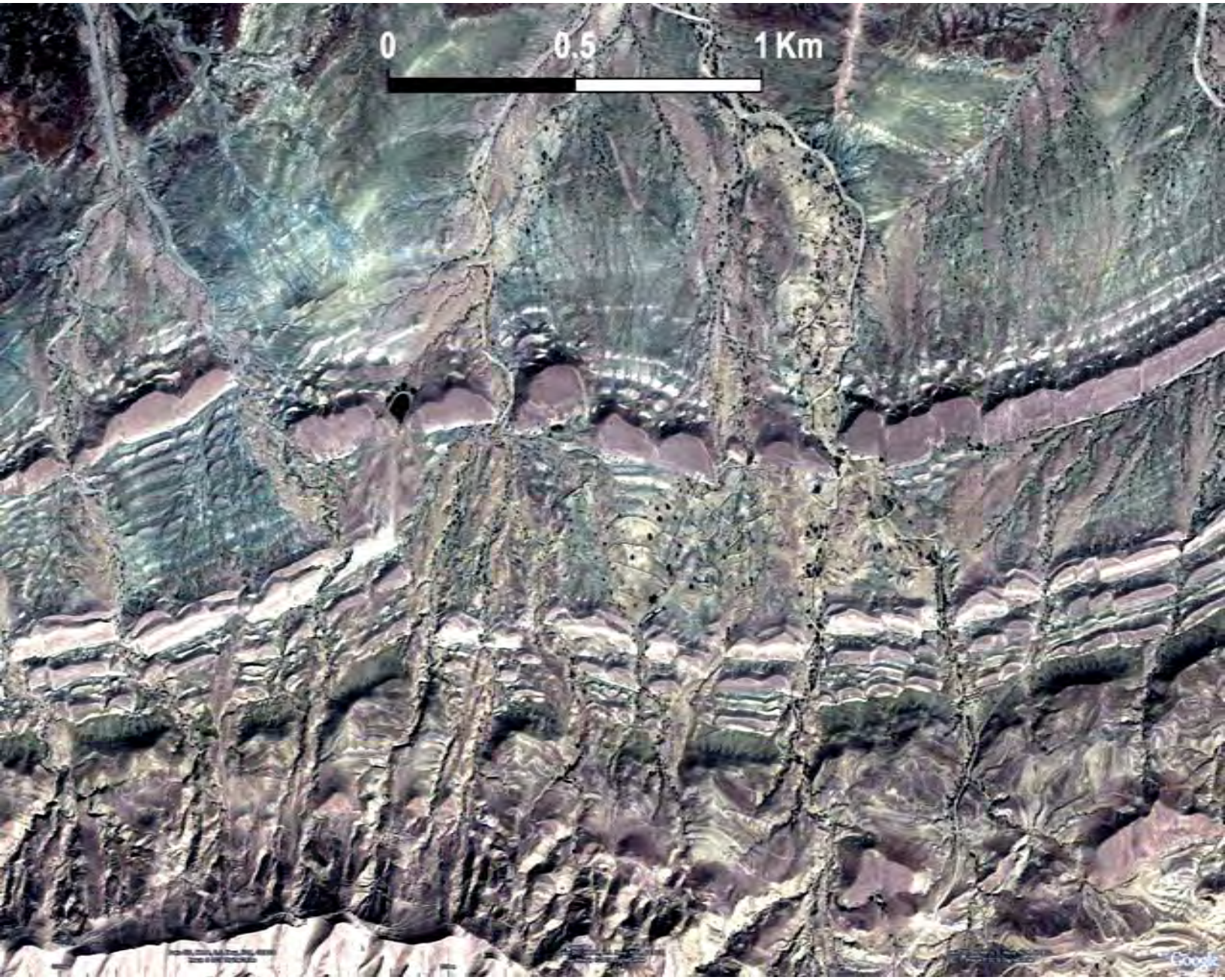


Cenozoic folded sedimentary rocks, Pakistan. The rock units are clear and can be easily mapped



Jurassic succession dipping east. Iran.
Notice the V shapes formed in the bedding planes.
Width of the image is about 500 m.

Faults



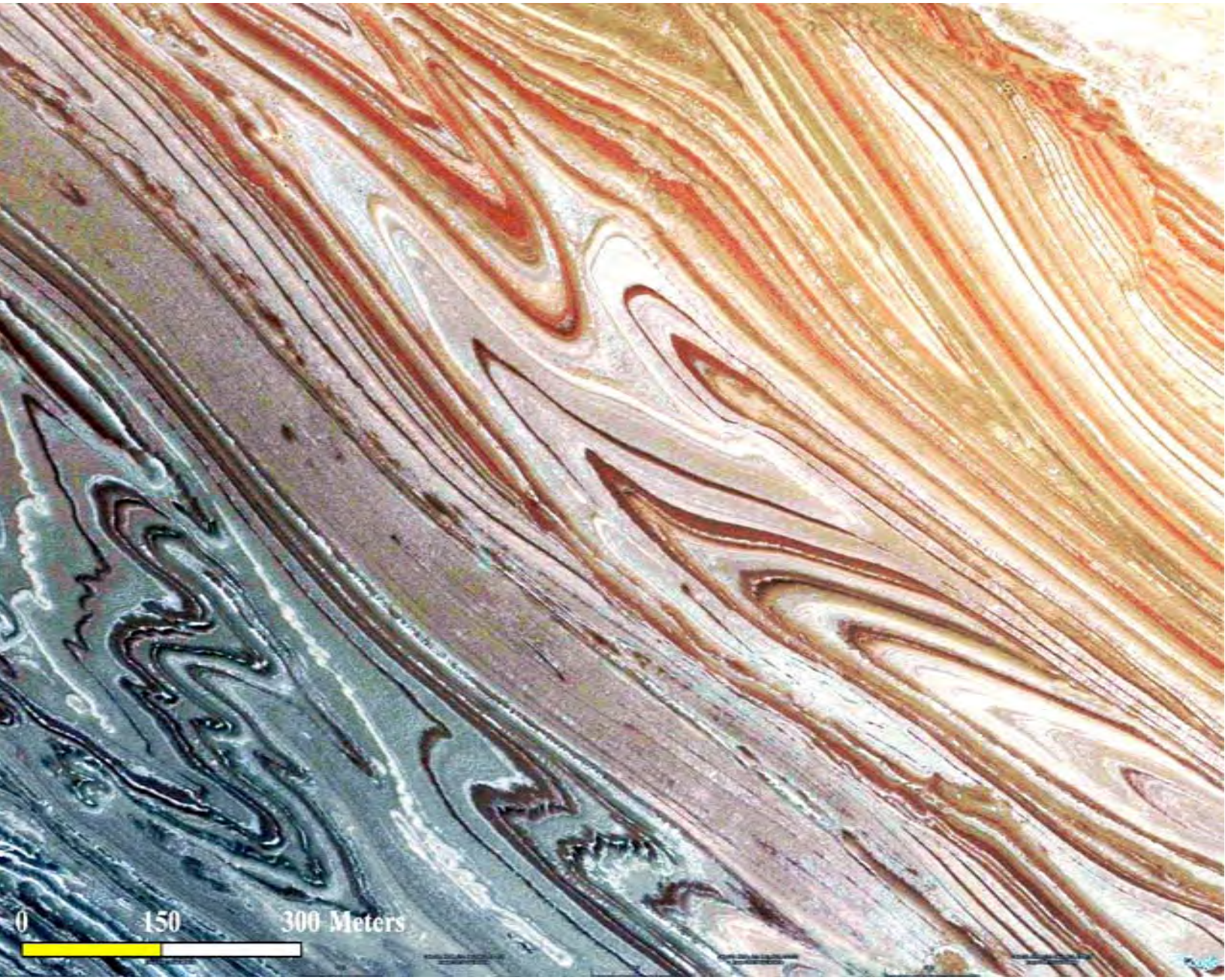
Highly faulted rock succession. Eocene, Pakistan

Master and minor faults. Jurassic, Iran
Notice the dragging of bedding along the master fault.

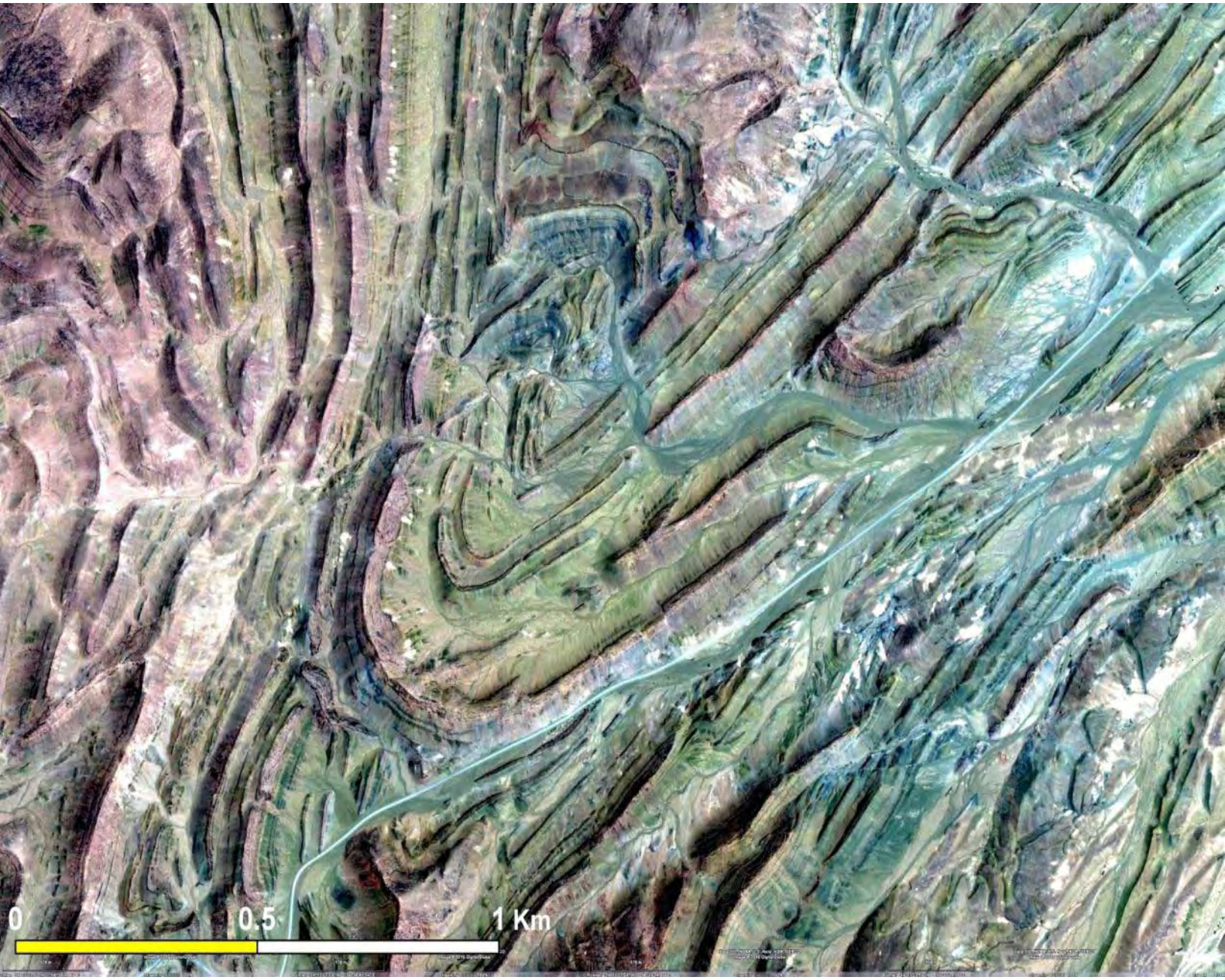
Intensive faulting in more than one trend realated to the same phase of deformation.Faults cam be easily interpreted and mapped. Cretaceous, Pakistan

Folds

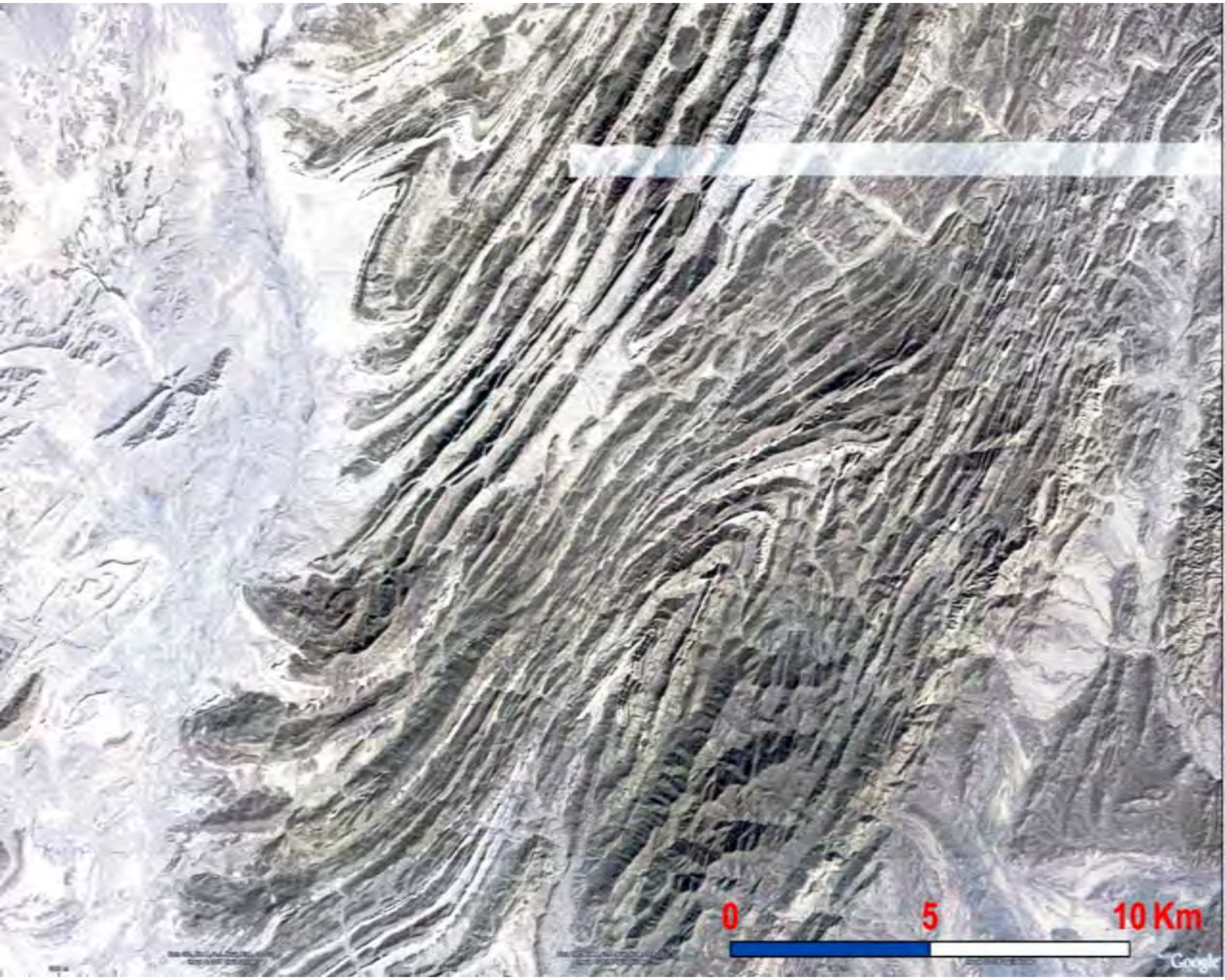
Anticlinal Fold in sedimentary succession. Notice, the direction of plunge to the SW, and the V shapes in the northern limb. Width of the image= 5 Km.



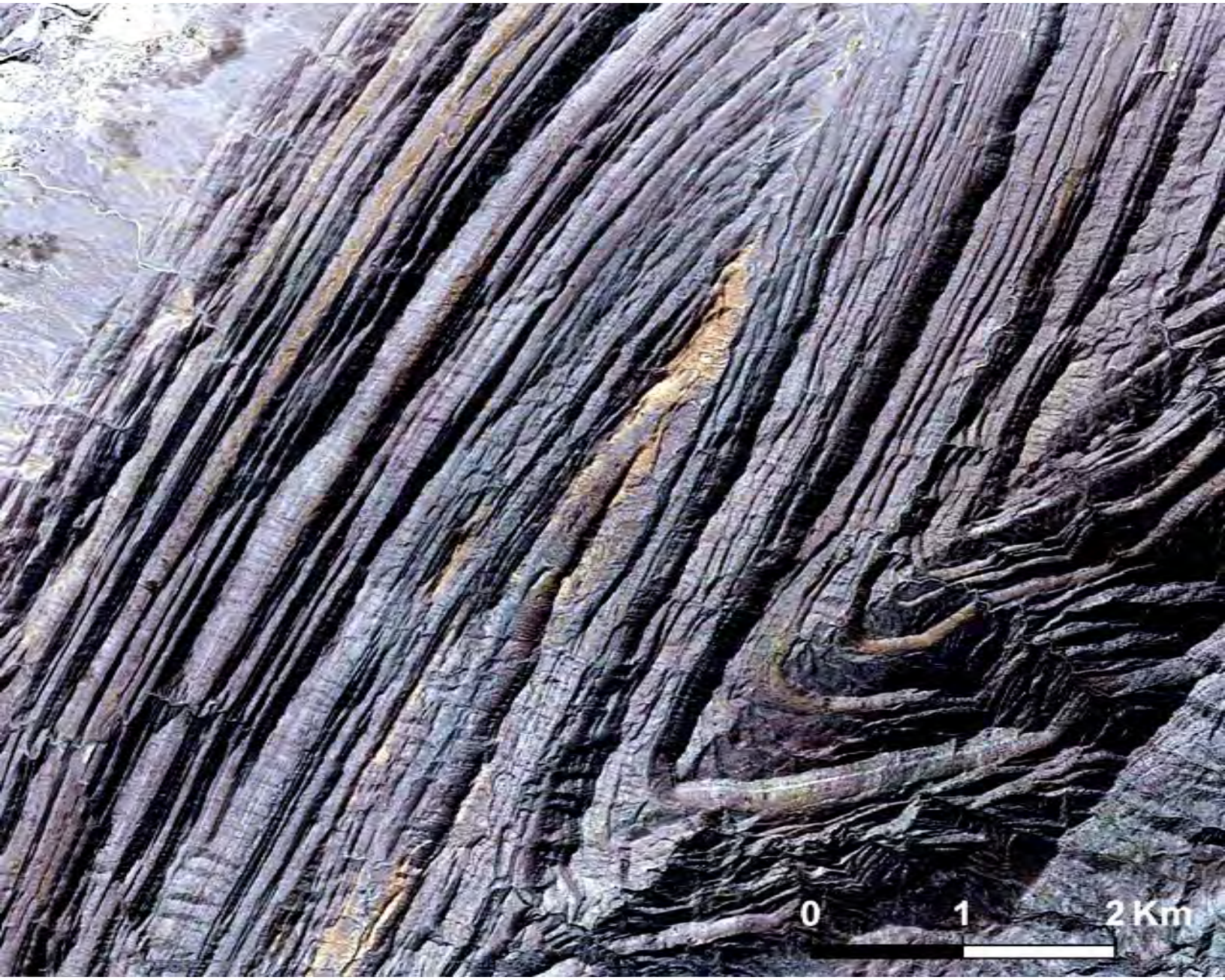
Disharmonic folding in Salt dome, Cenozoic, Iran



Synclinal fold Jurassic rocks, Iran. Notice, the variable intensity of erosion of the different beds due to the variation in its competency.



Major folding, Cretaceous, Pakistan

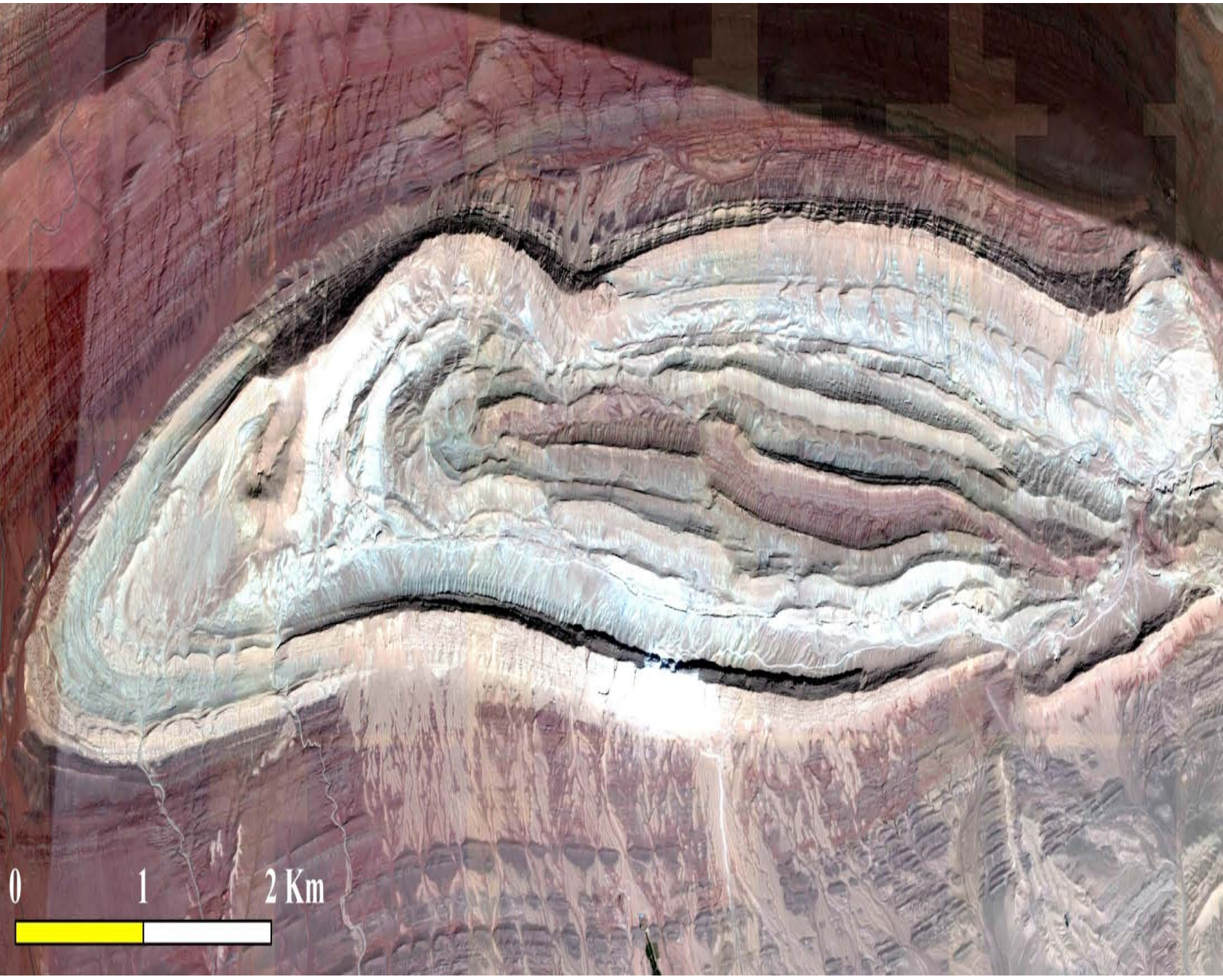


Major folding, Oligocene, Afghanistan. The dip of beds can not be determined in the image and must be checked in the field.

Folding in Eocene rocks, Afghanistan

Folding in Triassic rocks, Iran.
Notice some faults at the middle and southern part of the image

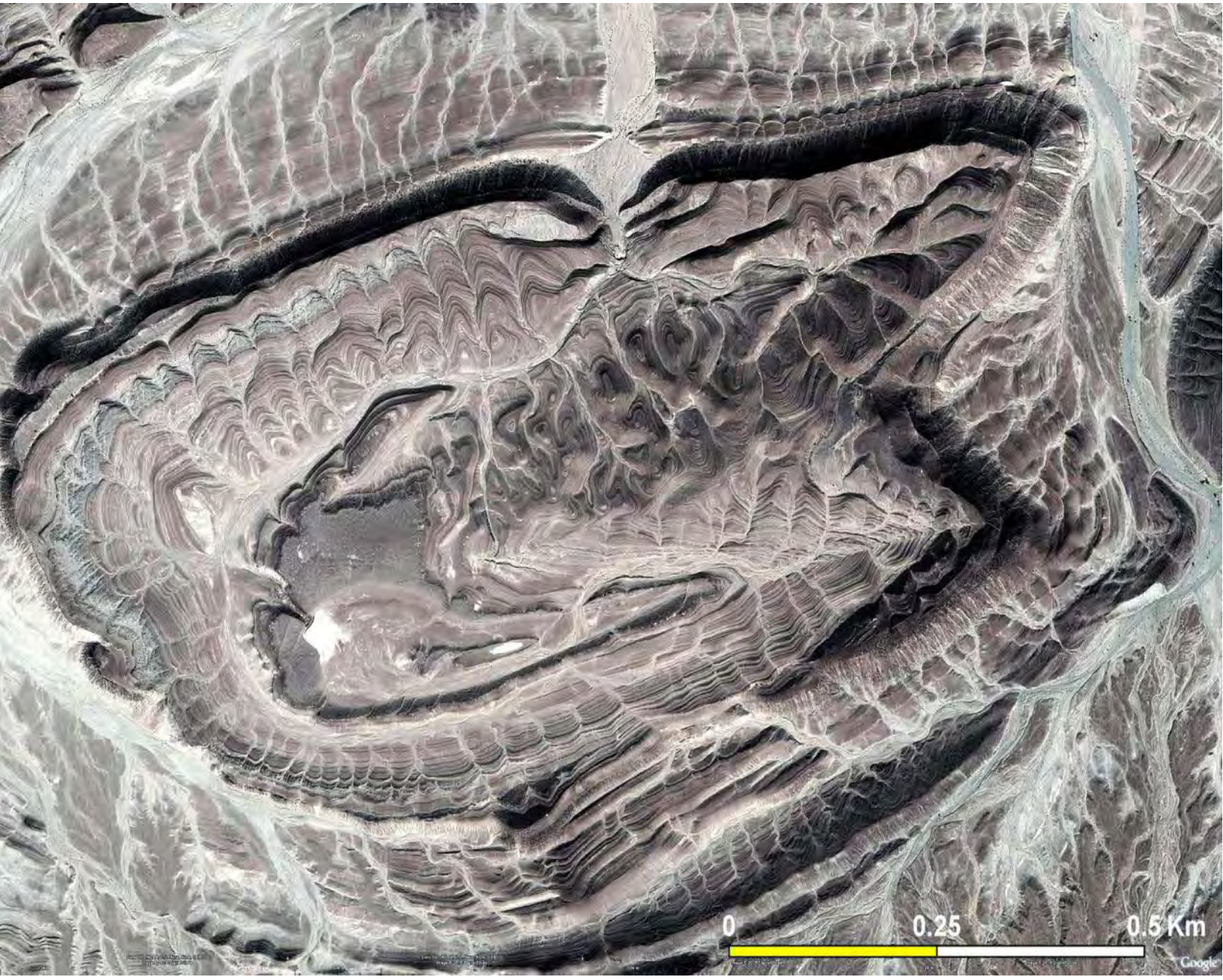
Folding in Jurassic rocks, Pakistan.
Notice the sharp hinges of the olds



Double plunging anticline in Miocene rocks, Iran.

Double plunging tight anticline, Miocene, Iran.
Notice, the V shapes in the southern limb.

Basin structure, Eocene, Pakistan. For details, see the next slide.

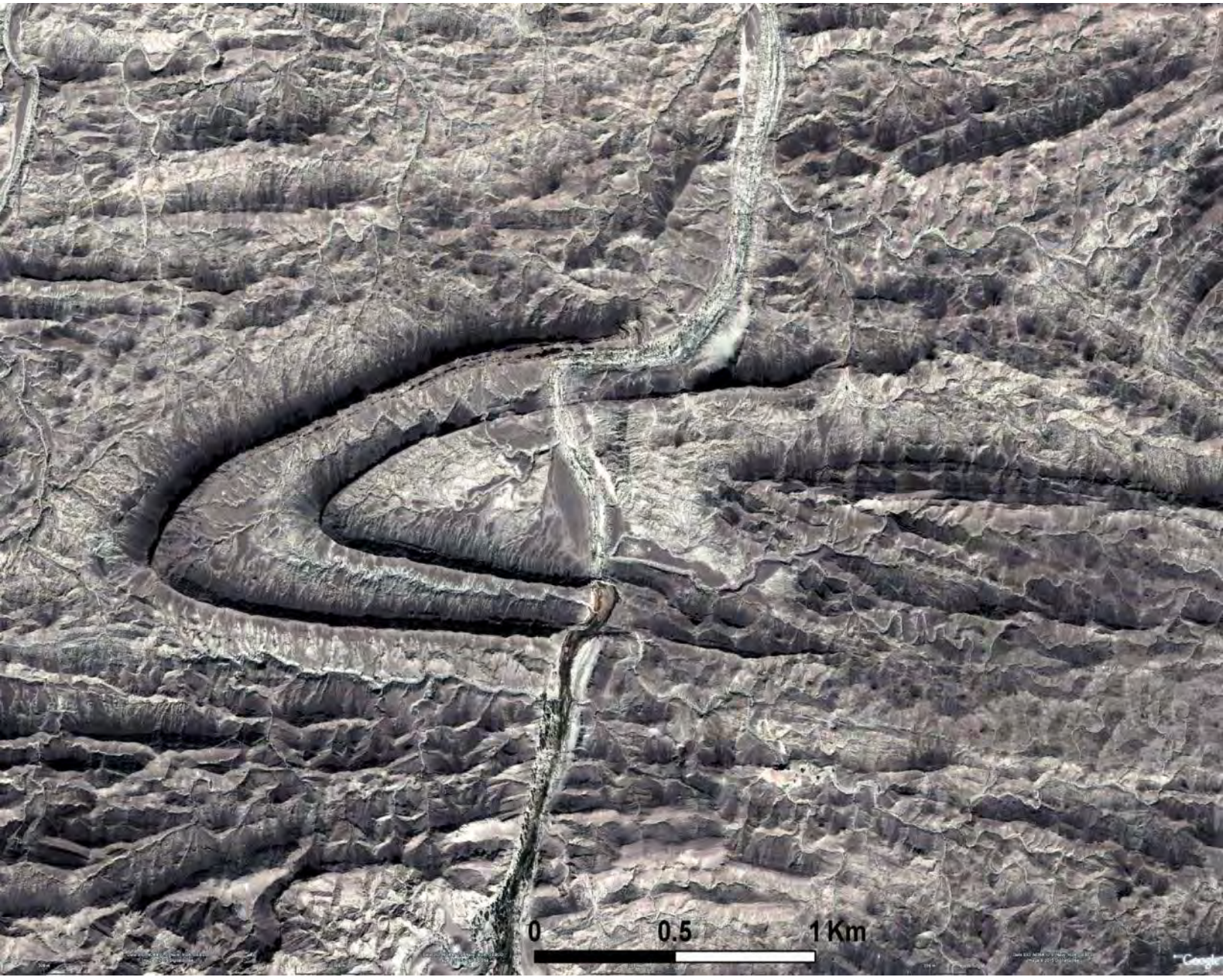


Close up view of inner part of the basin shown in the previous slide.

Complex folding, Cretaceous, Iran

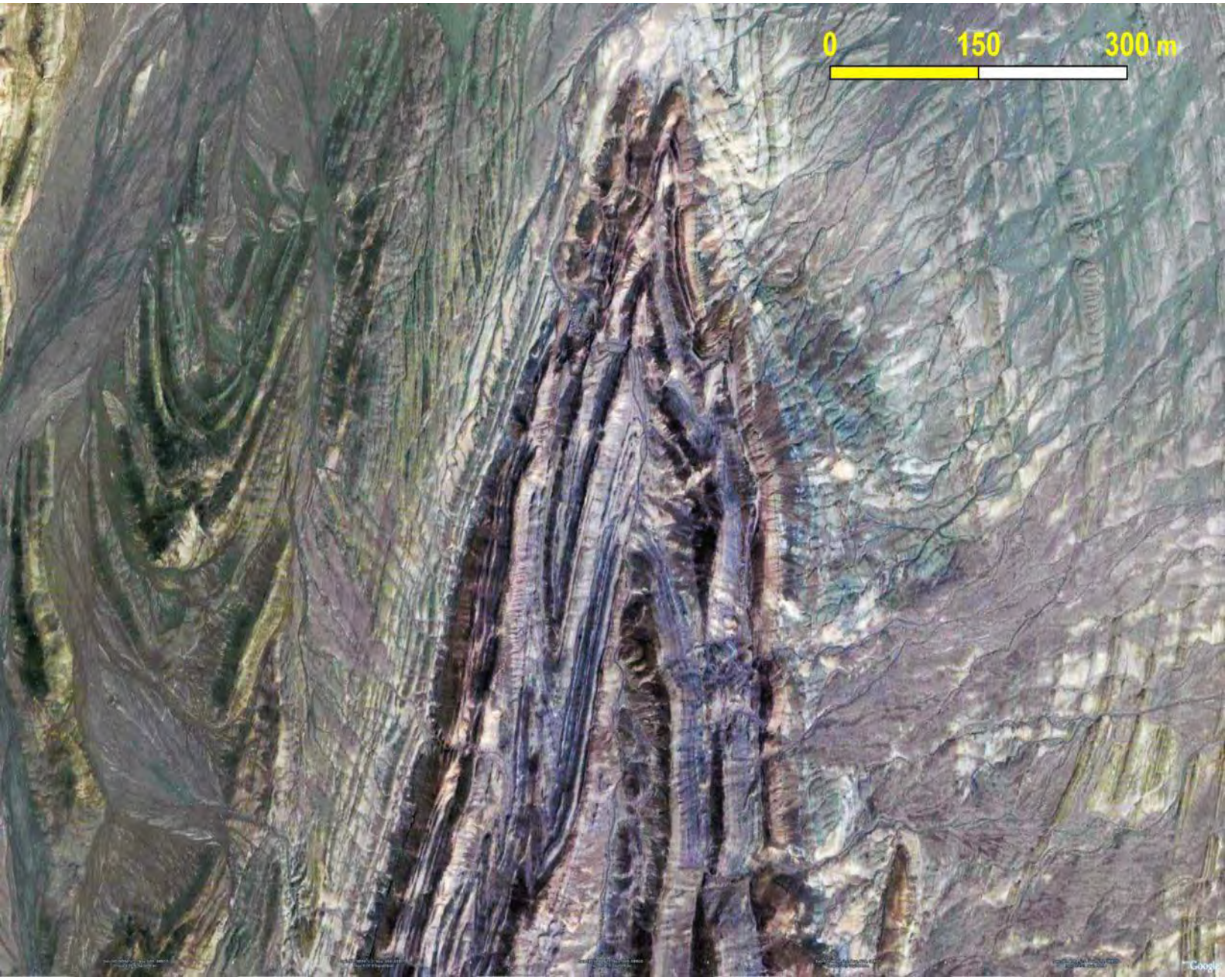
Refolded folds

Refolded fold. Miocene, Iran



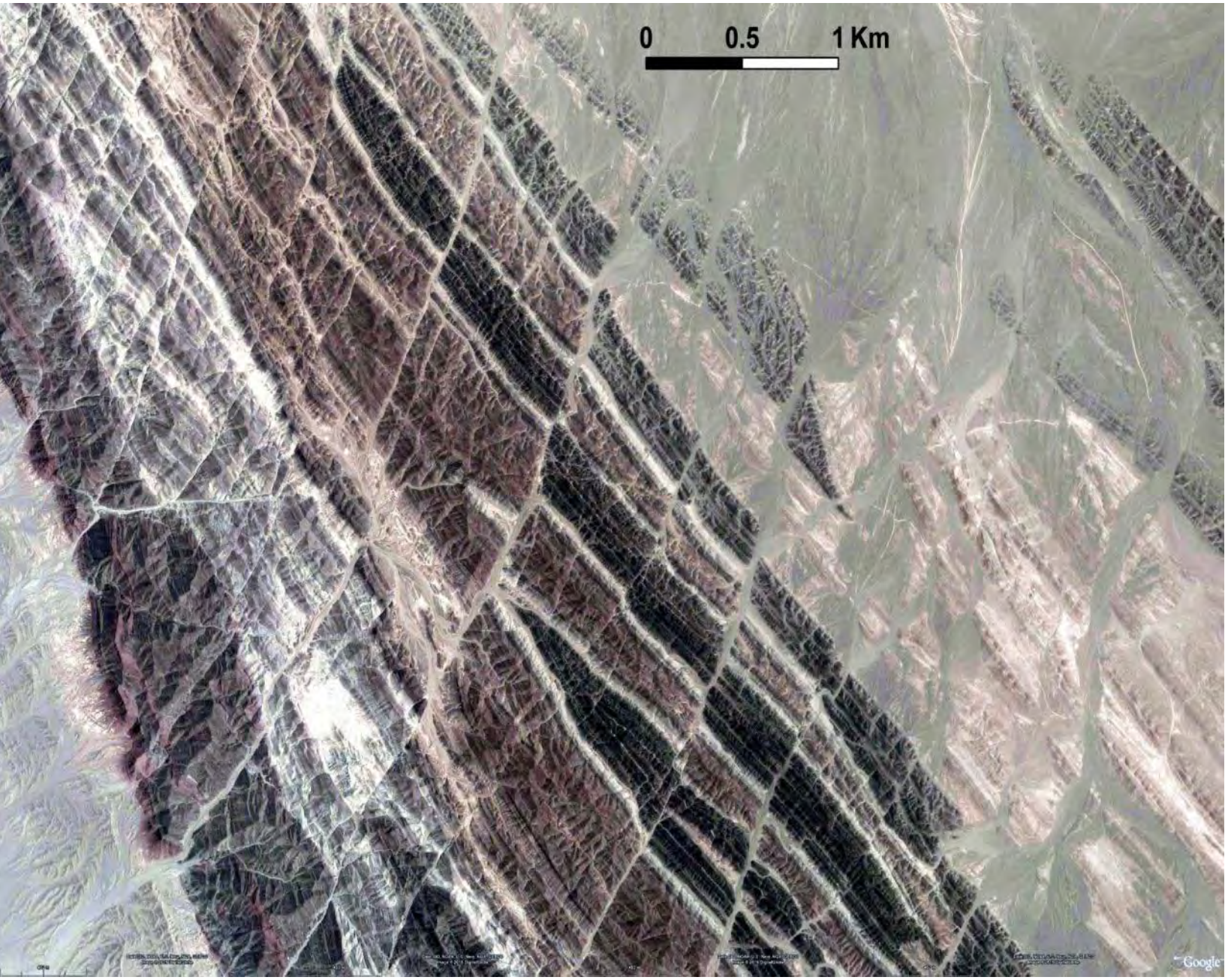
Refolded fold. Eocene, Iran.

Refolded fold. Cretaceous. Pakistan.



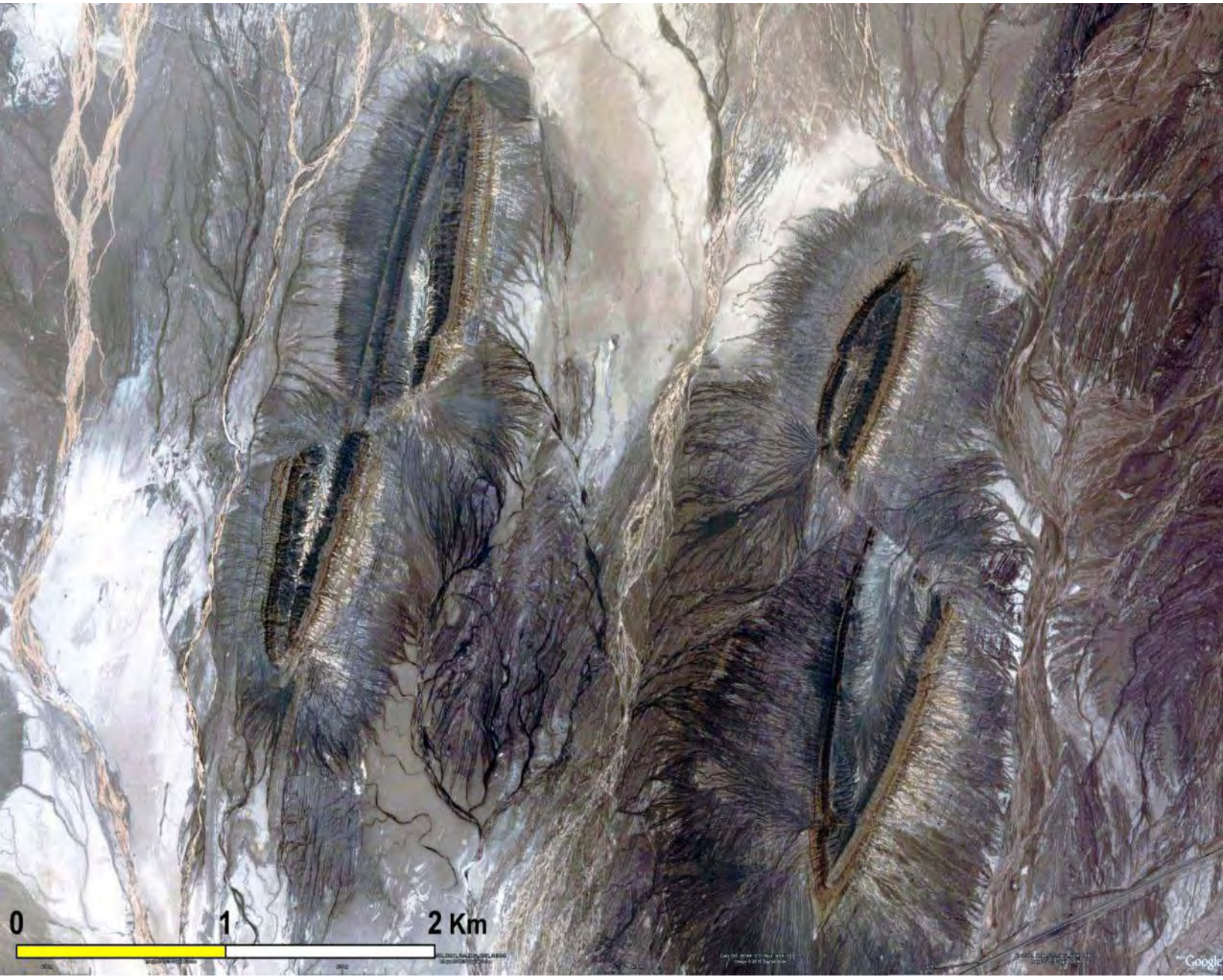
Refolding in Jurassic rocks, Iran.

Faulted folds

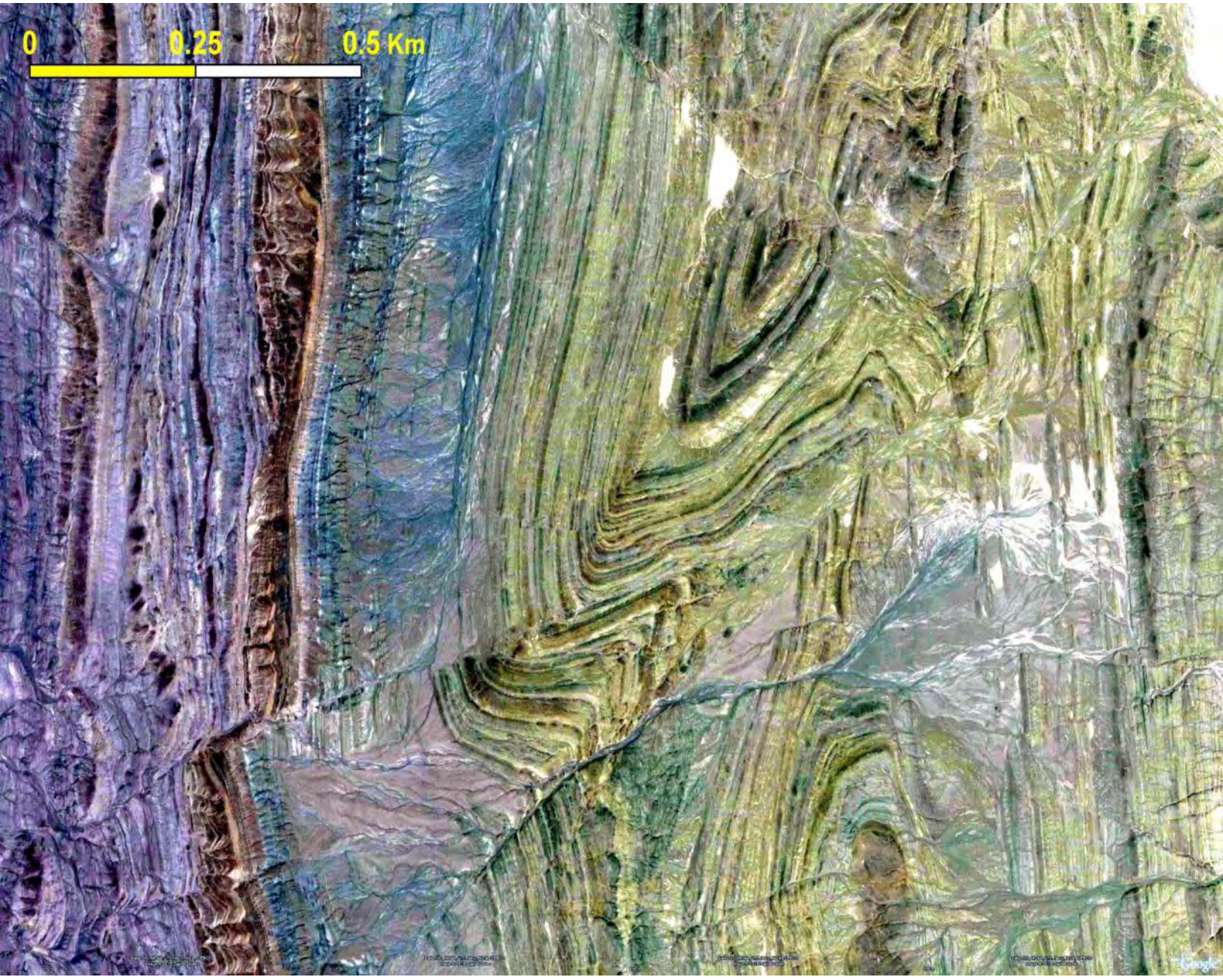


Intensive faulting in Eocene, Pakistan.

Two conjugate faults affecting a major fold. Jurassic, Pakistan



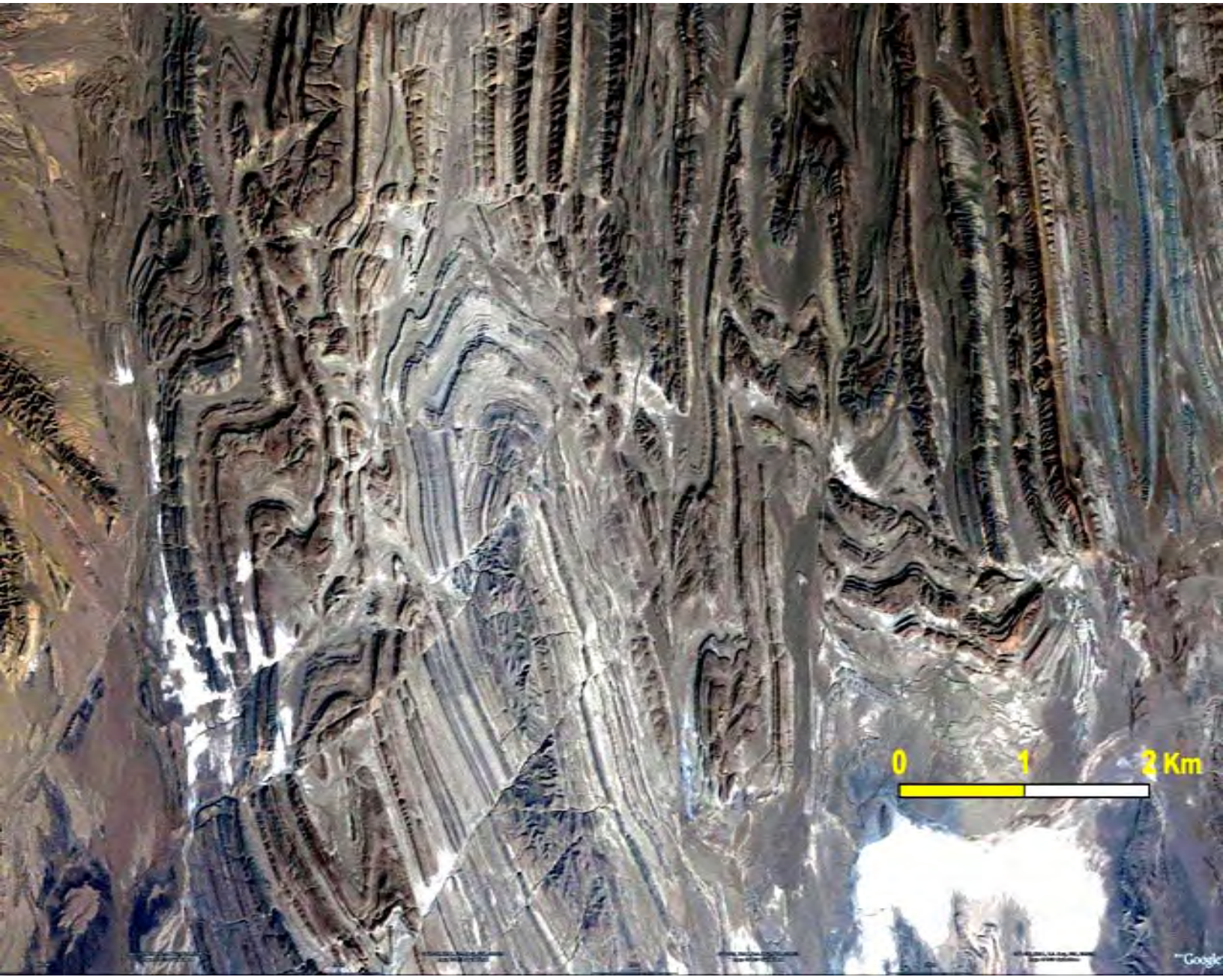
Two conjugate faults affecting double plunging folds. Jurassic, Iran.



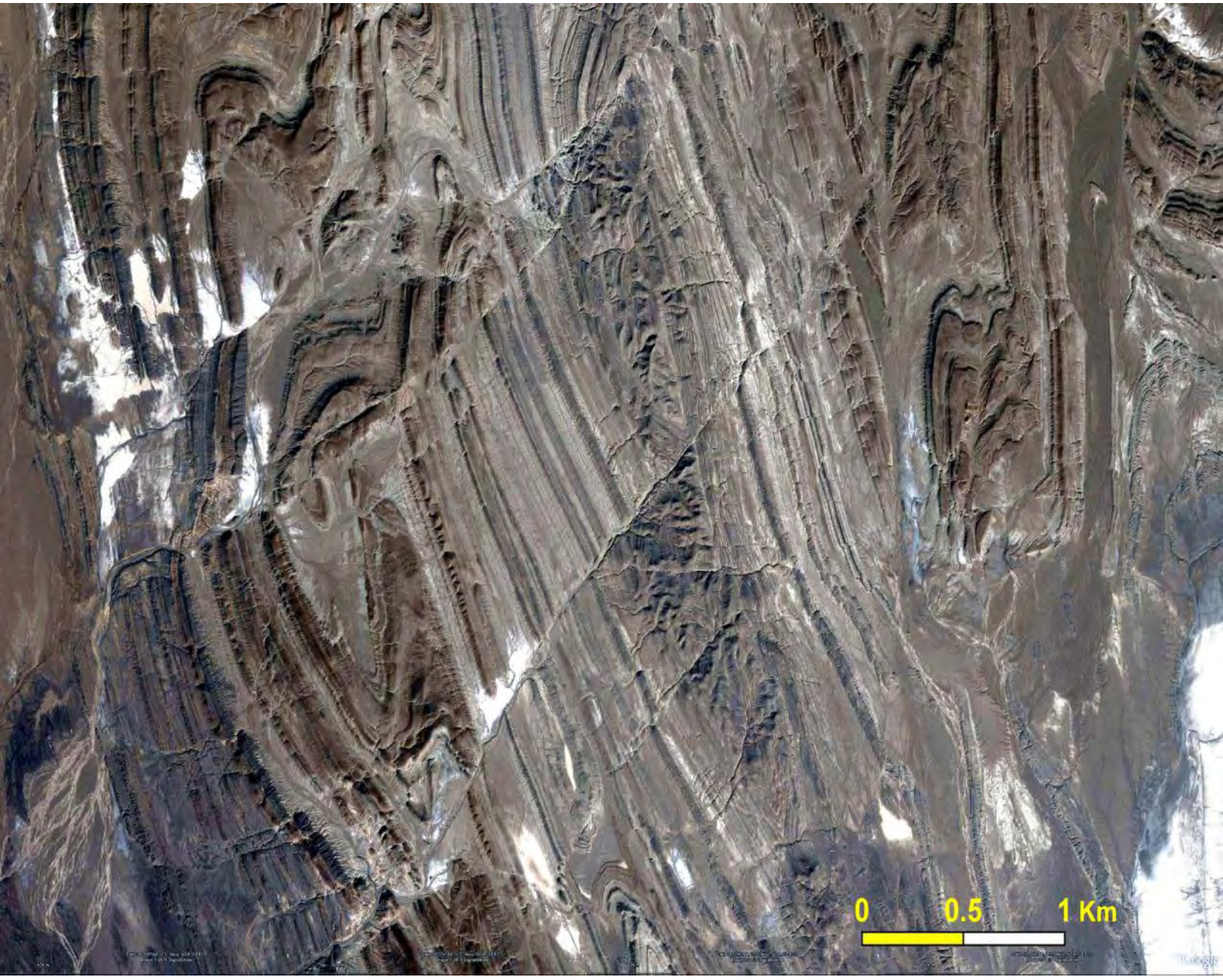
Faulting along NE and NW trends. Jurassic, Iran.

An asphaltic road running along a fault plane affecting a refolded fold. Jurassic, Iran.

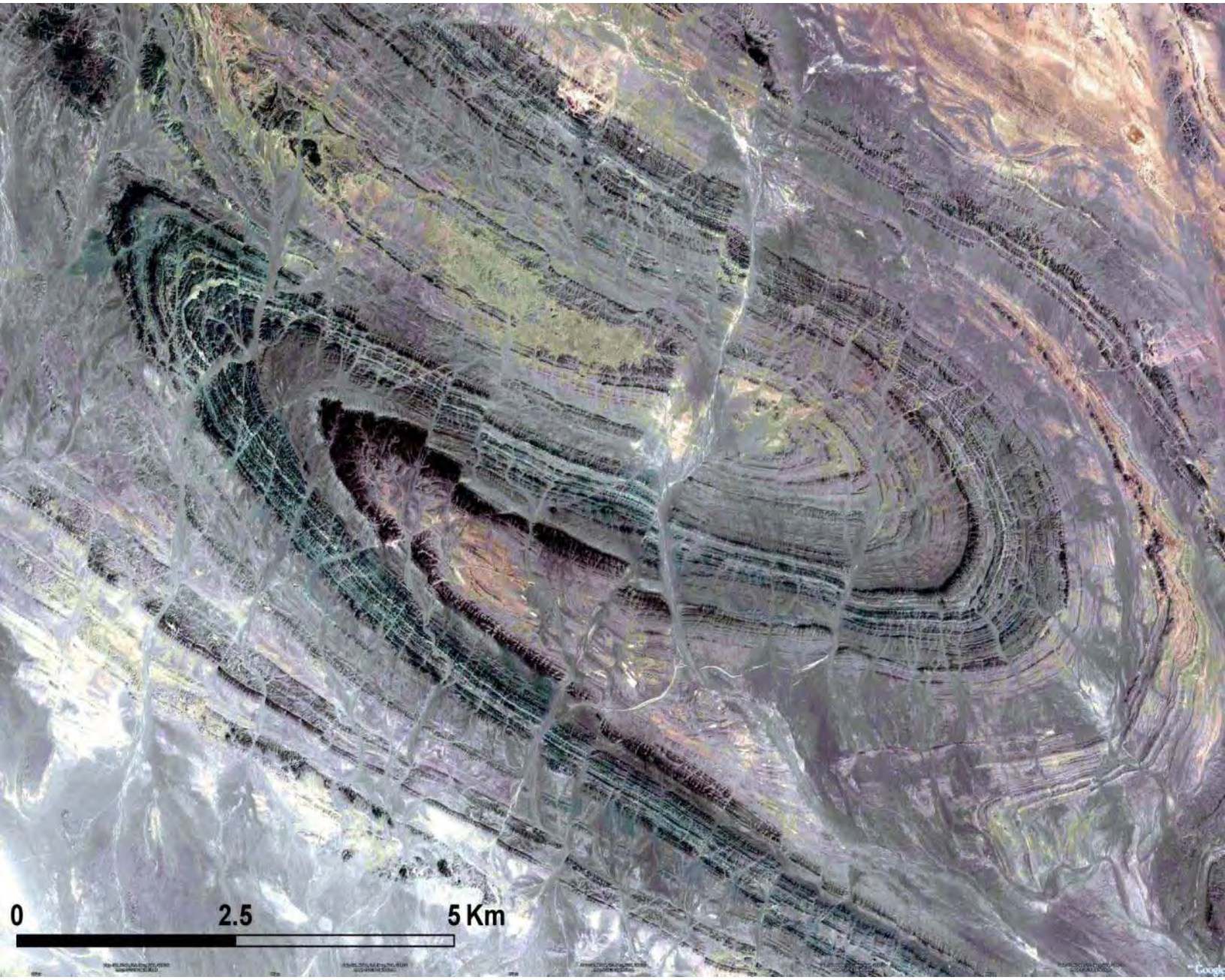
An asphaltic road running along a part of a fault affecting a major fold. Jurassic, Iran.T he previous slide constitutes the eastern part of the present image.



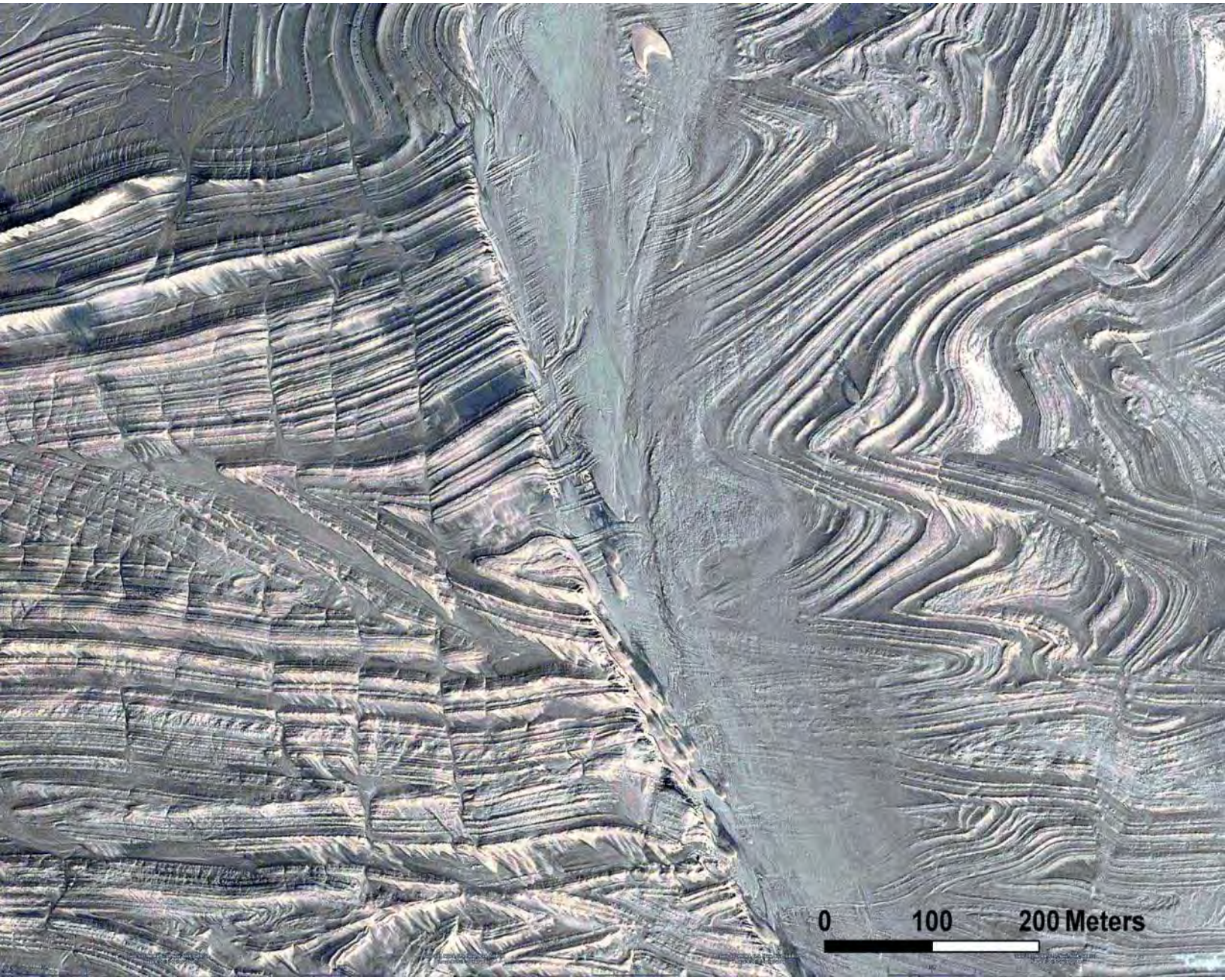
Major folding and faulting in Triassic Rocks. Iran.



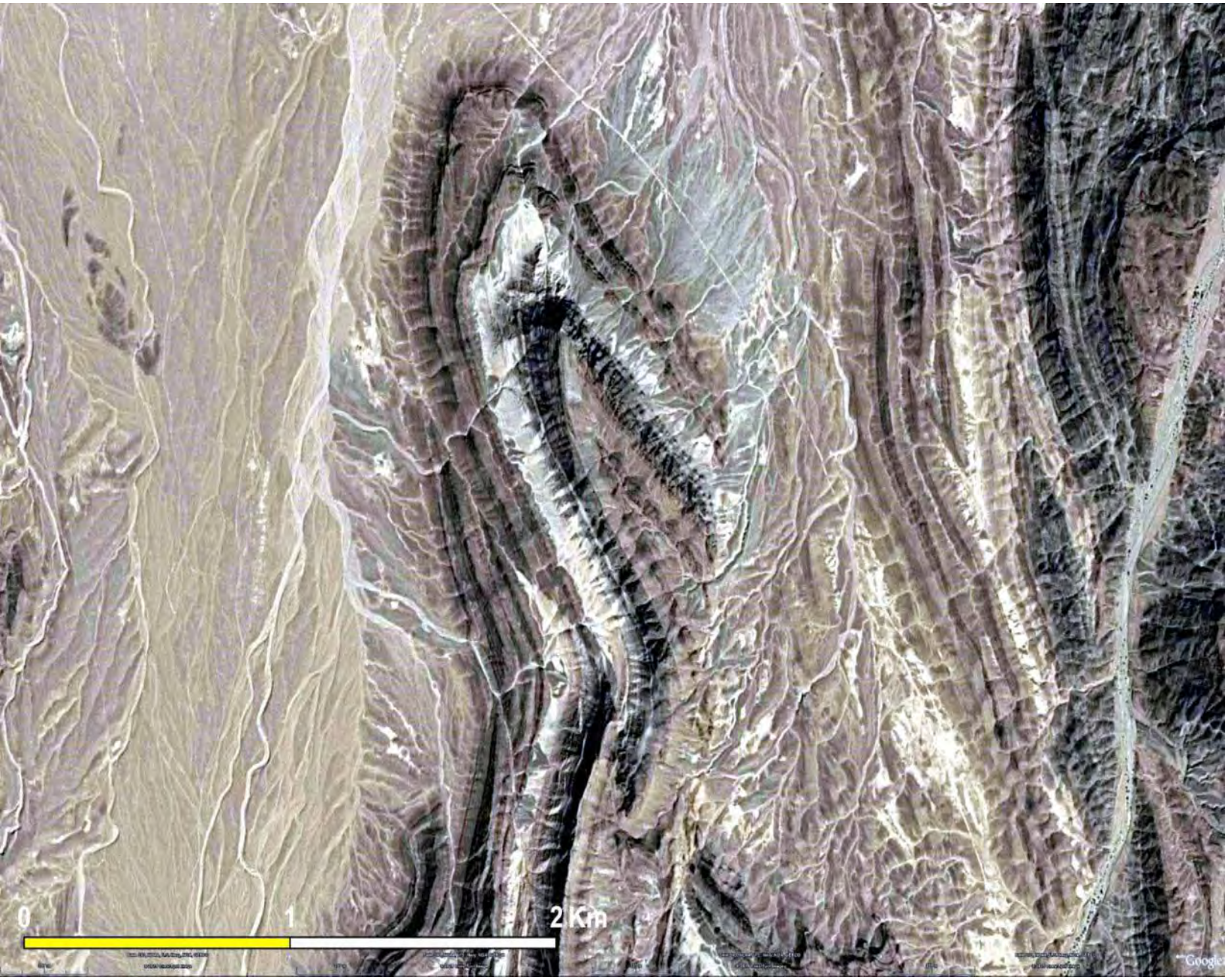
zoom of the previous image



Transverse faults affecting major folds. Pliocene, Iran.



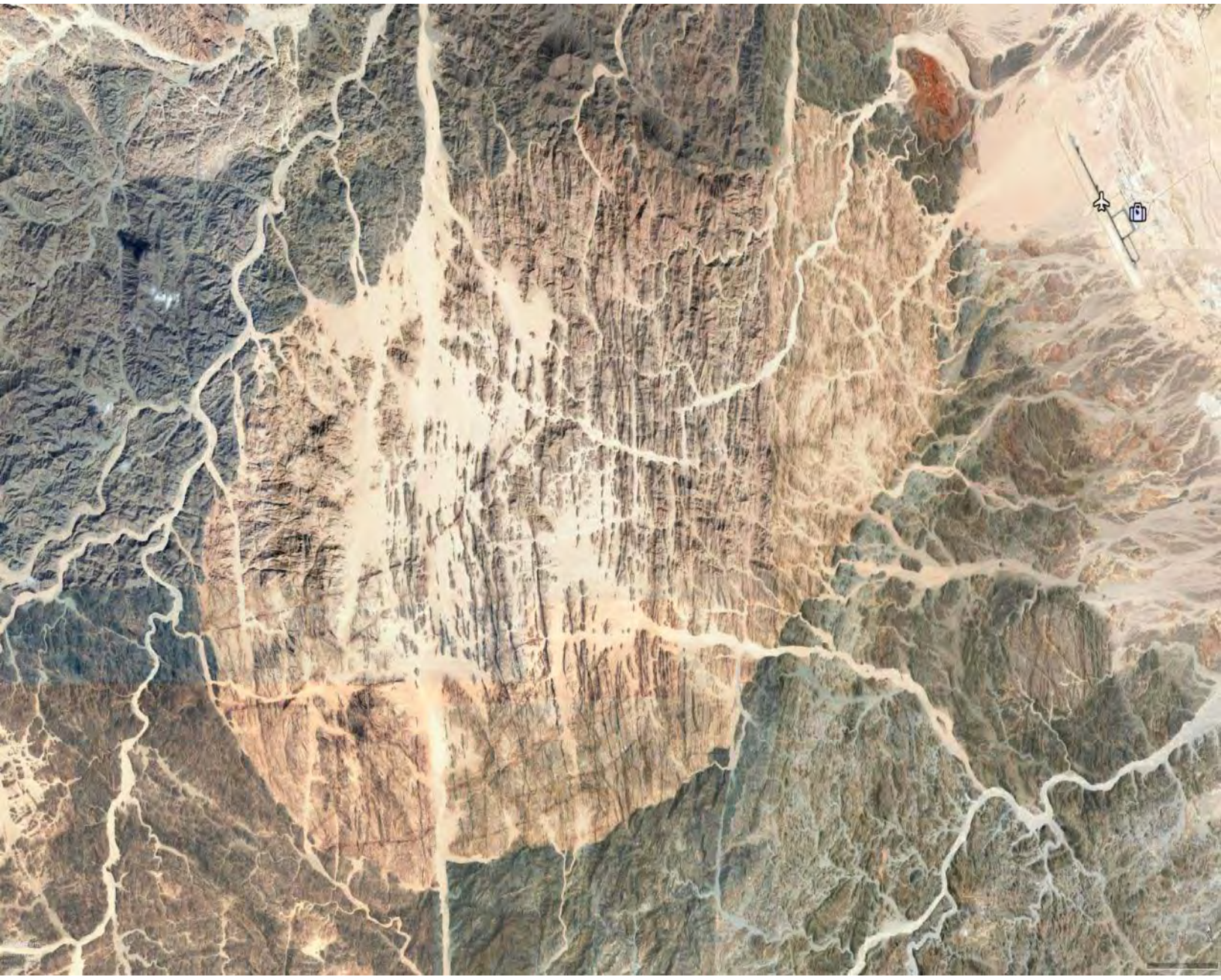
A fault marked by the discontinuity of structures on broth sides of the fault. Pliocene, Pakistan.



A fault cutting oblique to the fold axial plane. Cretaceous, Iran.

Bsement rocks

Several granitic masses intruding the metavolcanics. Eastern Desert, Egypt. Width of the image is about 60 km.

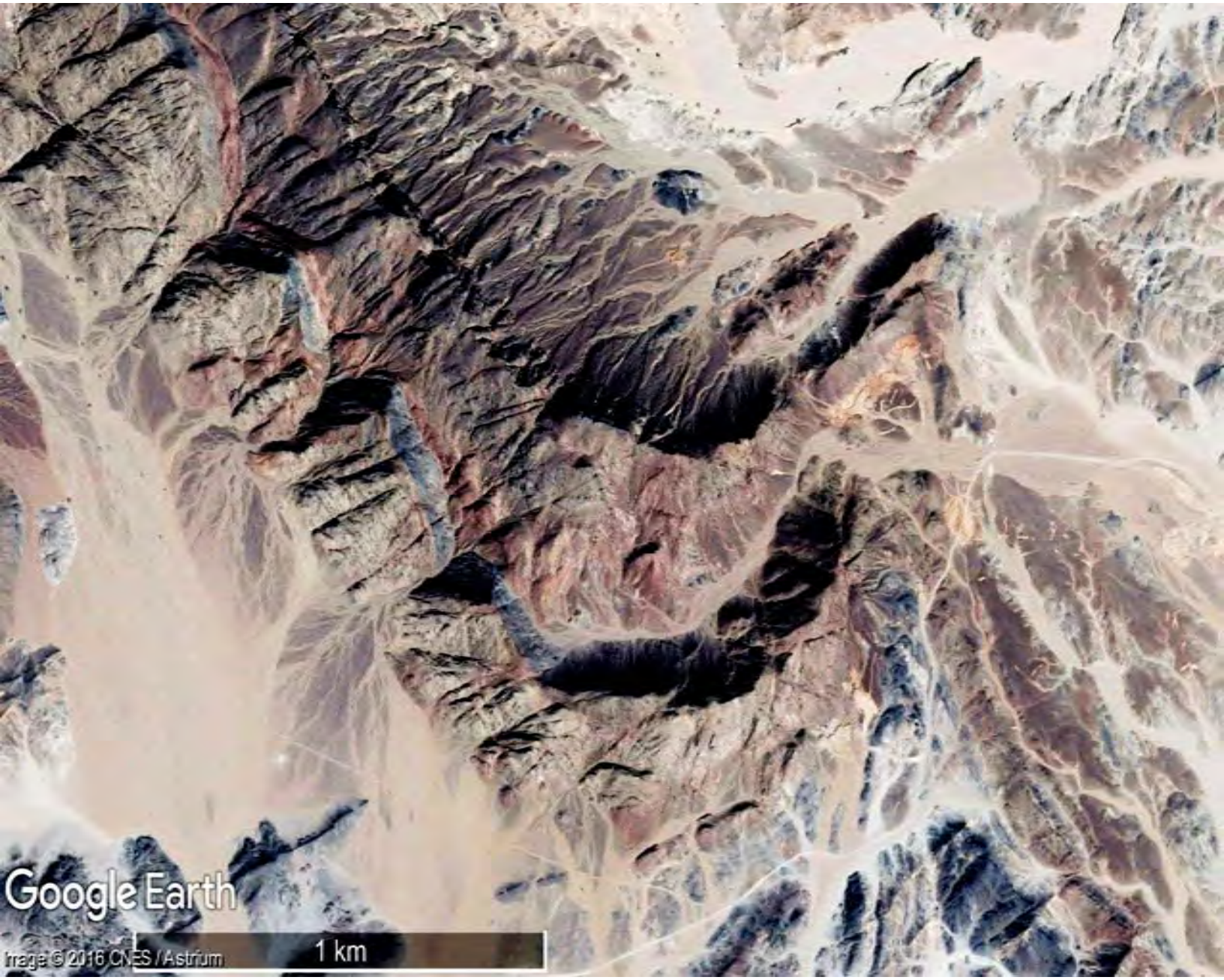


Zoom of the previous image. Gabal Kadabora granite intruding metavcolcanics. The width of the granitic mass is about 22 km. The elongated lines in the granite are dykes. Notice, the sharp contact and the younger faults affecting both units.

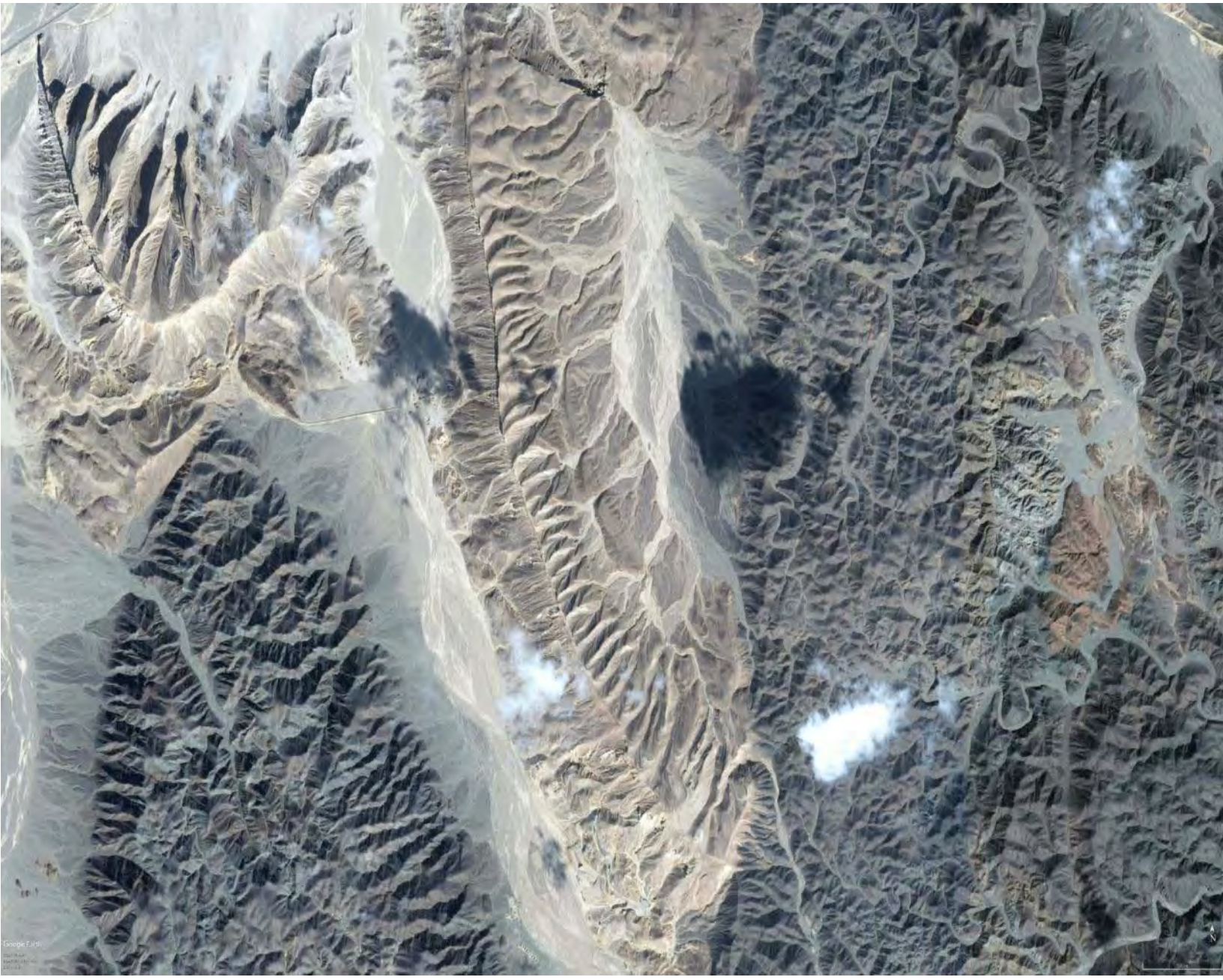
Zoom on the previous image, showing the dykes affecting the granite.

Miocene sediments within the Basement rocks preserved along a fault plane. Eastern Desert, Egypt.

Miocene sediments within the Basement rocks preserved along a fault plane. Eastern Desert, Egypt.



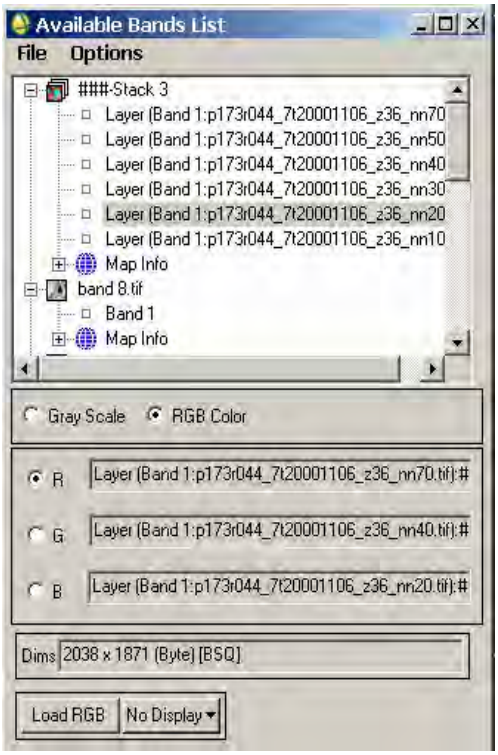
Refolded fold in psammitic gneisses. Hafafit area, Eastern Desert, Egypt.



Notice. The two masses of clouds (white small areas) and their black shadow on the ground. The two black spots on the central part of the image do not indicate lithologic variation.
The width of the image is about 1 Km.

VI- Merging of images (Data Fusion)

This process is to combine the color-composite (false color) TM image of resolution 30 m with another monochromatic image of higher resolution (e.g. band 8 TM image of resolution 15 m). This will produce a new image of the same color variation as the TM false color image and has the higher resolution of band 8 (15 m).



Procedure:

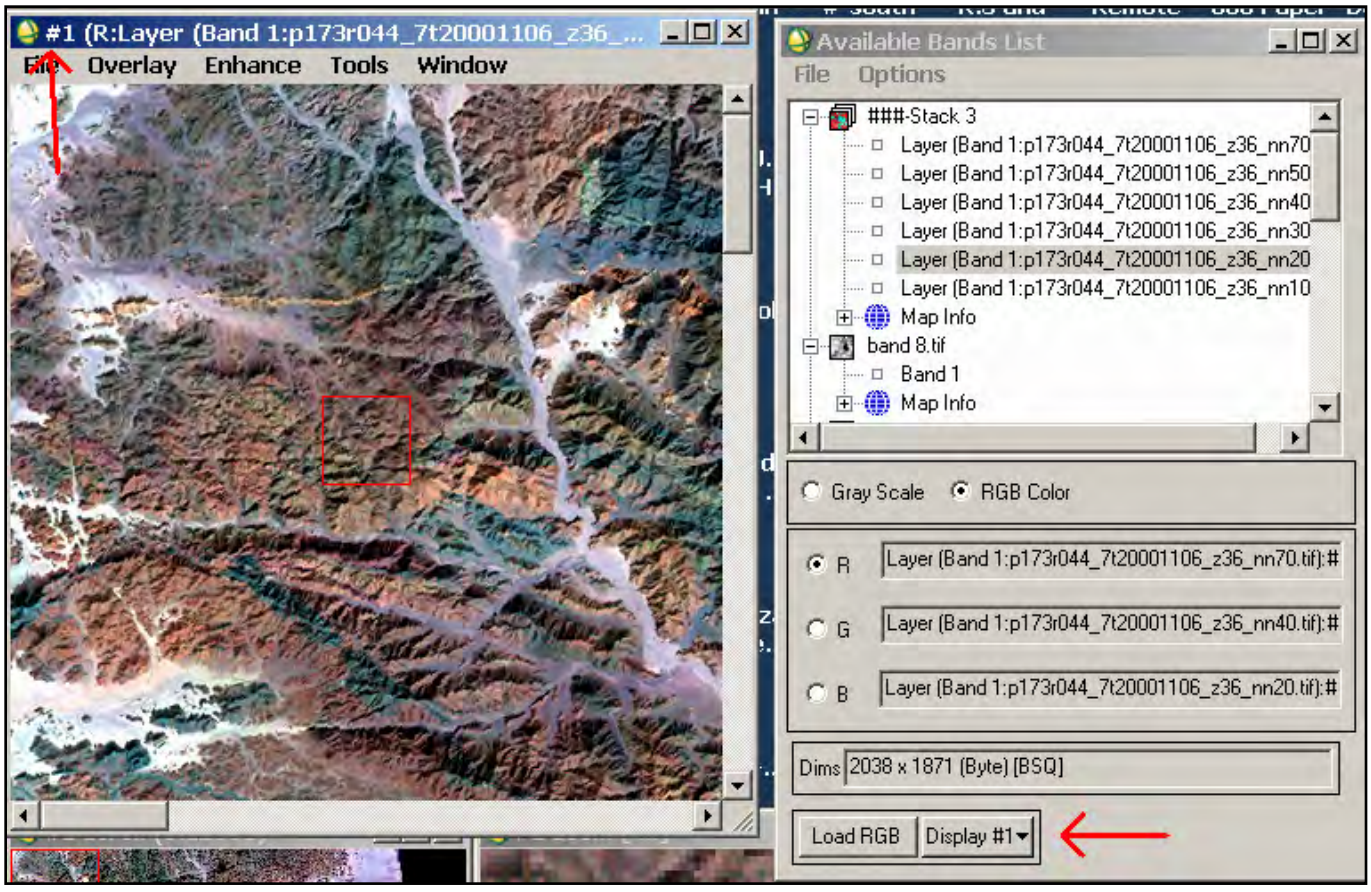
1- You are provided with two files:

a- **###-Stack 3** : is a stack file containing 6 TM bands of a selected area. the file is an Envi standard file (has no extension)

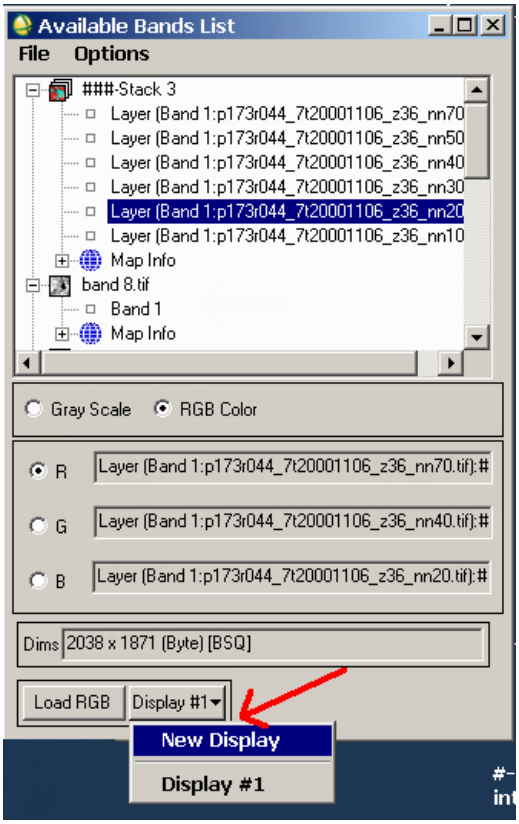
b- **Band 8.tif** : is a tiff file containing band 8 of the same area represented in the stack file.

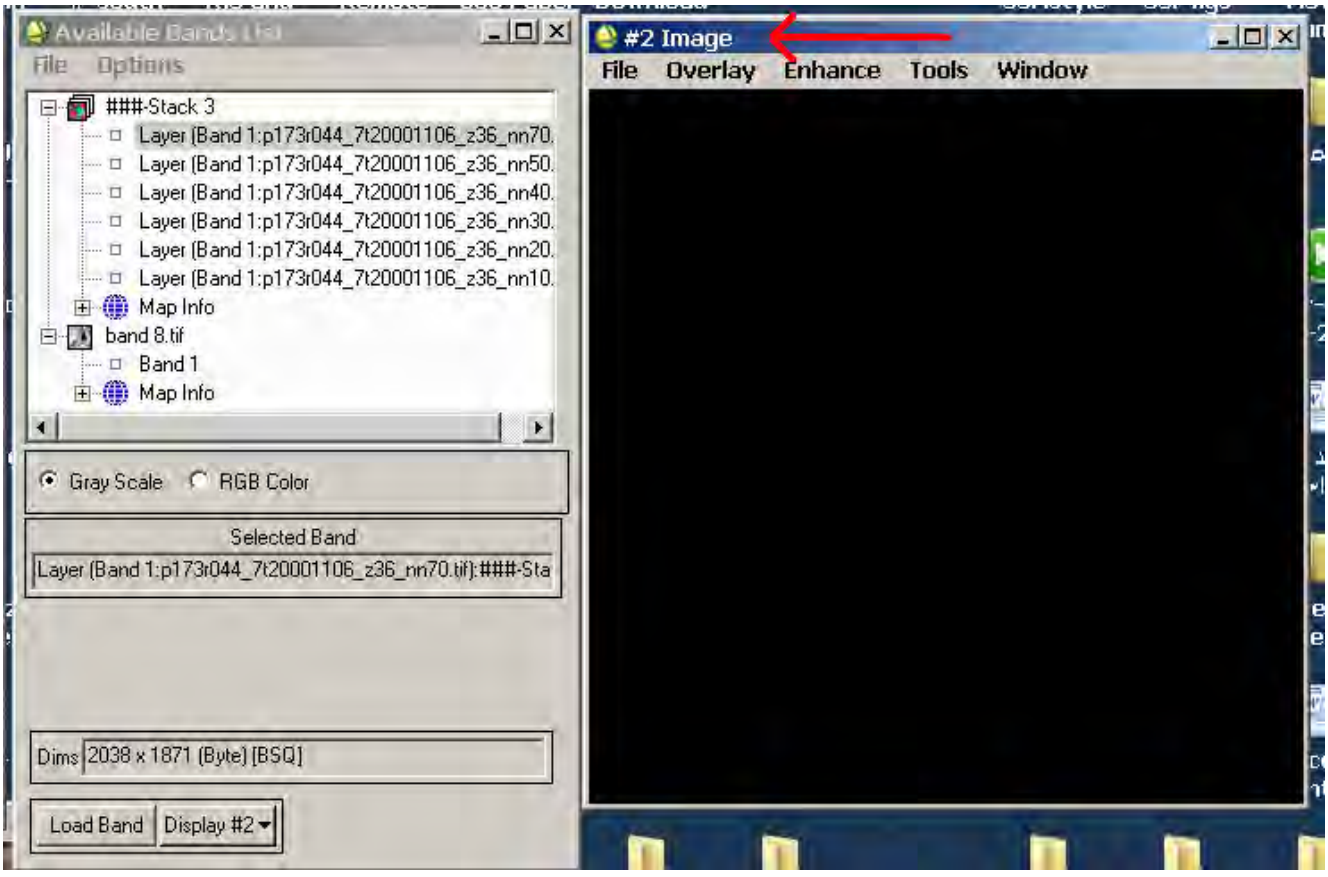
2- Open the two files in Envi. The two files appear in the "Available bands list" box.

3- Then Load the band combination 7,4,2 from the stack file and make your enhancement to get the best image. The image will be shown in a display number #1.



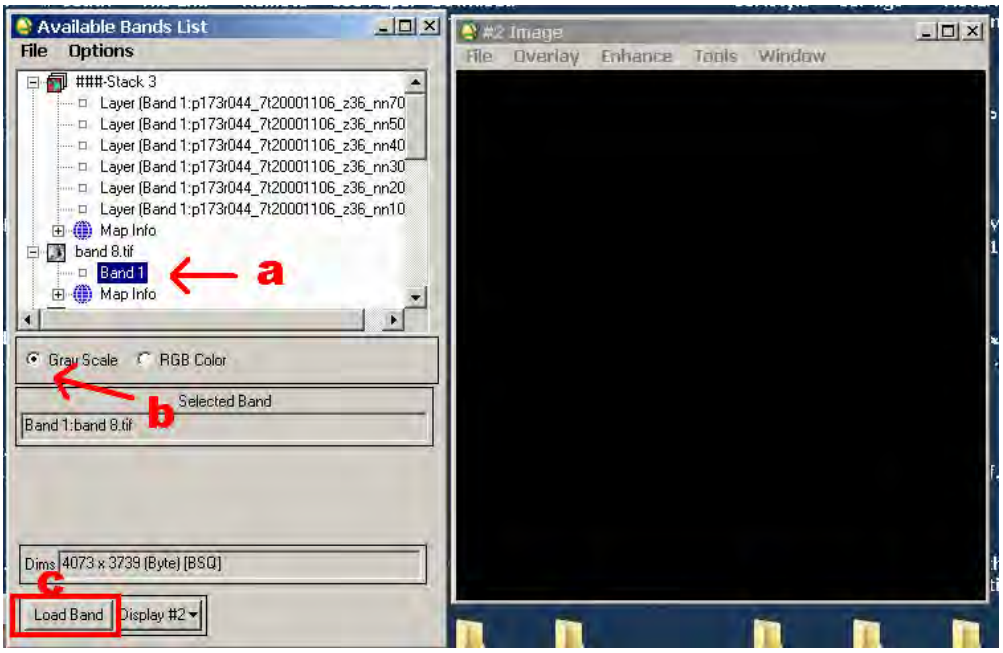
4- Open a new display window to load (band 8) in it as follow:
Press “Display / New Display”. This opens a new empty display window (#2).



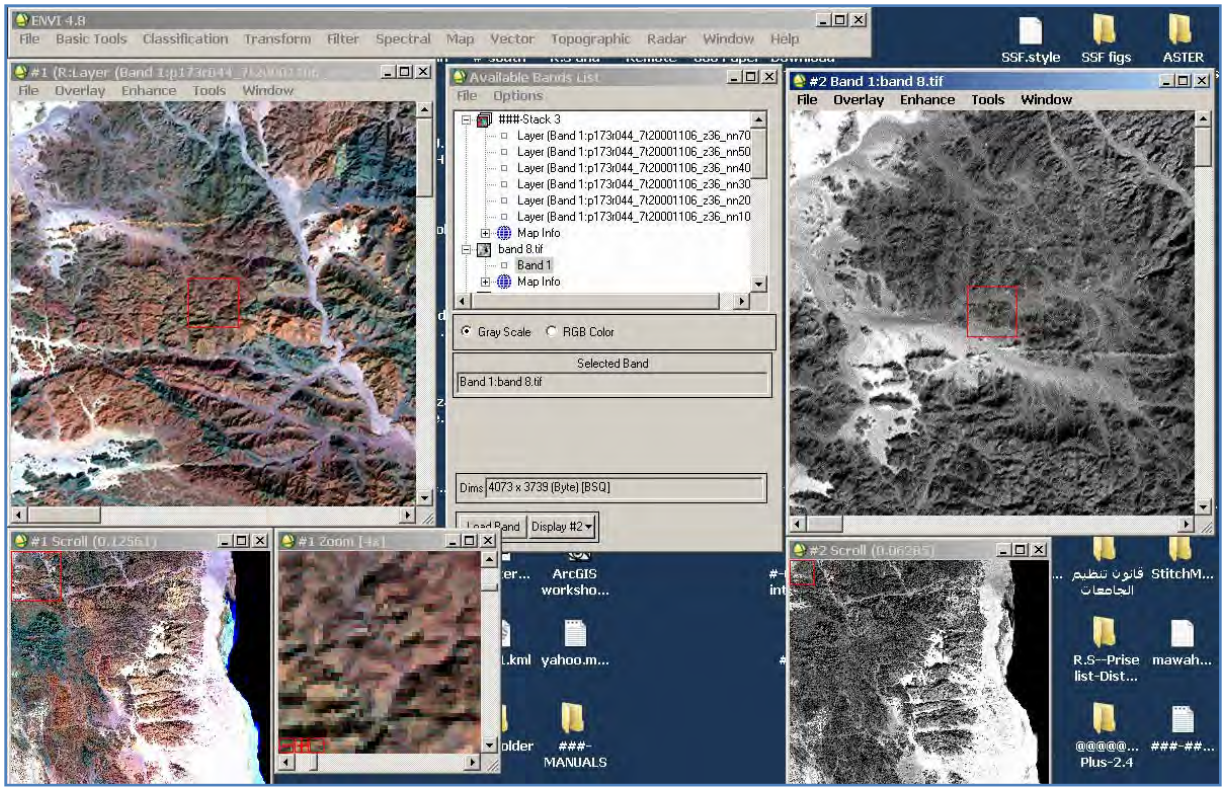


5- Load band 8 in the new window. To do this:

a- Select the file “band 8.tif”
b- select “Grey Scale” (because band 8 is monochromatic)
c- Press the button “Load band”.

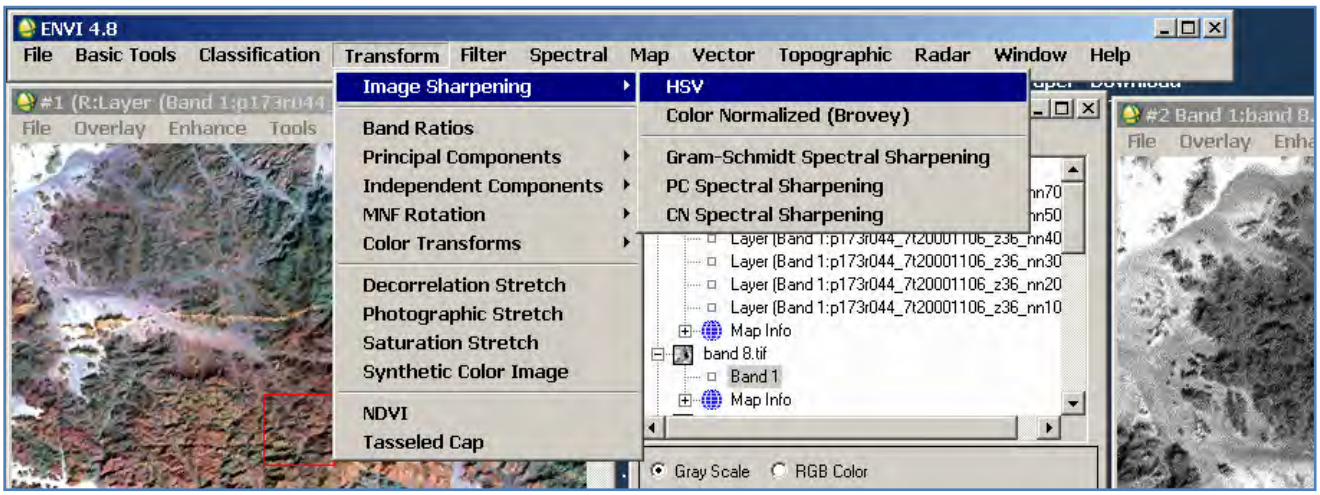


6- This will load band 8 in the new display window. Now, you have the two images (7,4,2 image and band 8 image) loaded in two separate widows (Window #1 and #2). Make enhancement on band 8 image for best result.



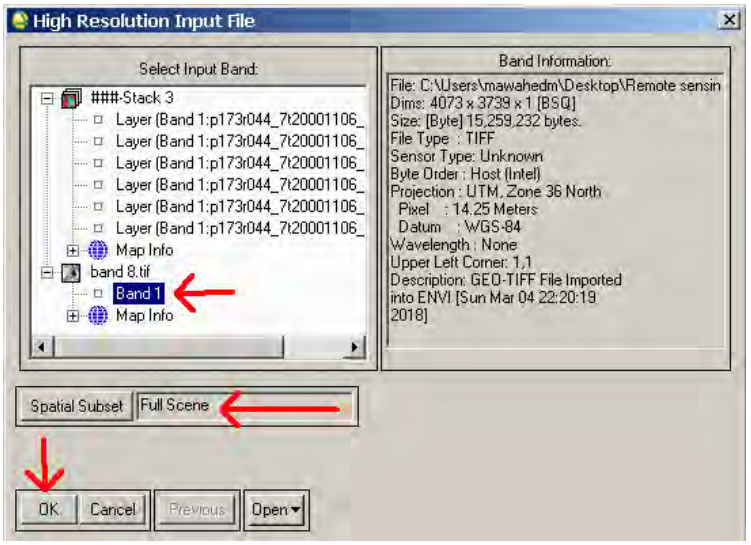
7- **Now you are ready start the process of merging the two images**.

8- Press "**Transform / Image sharpening / HSV**"

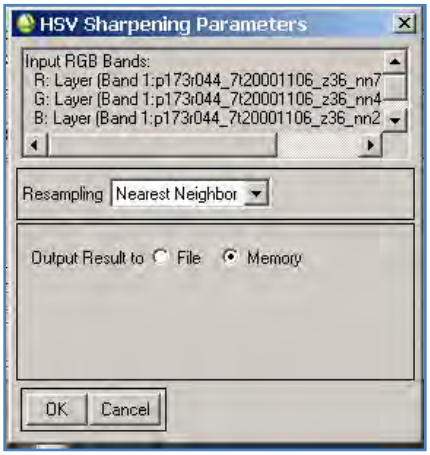


9- The "select input RGB" box appears. Select (**Display #1**) because it contains the RGB image. Press "ok".

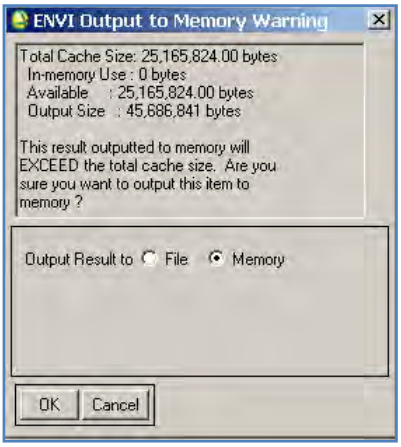
10- The "High resolution input file" box appears. **Select bad 8.** Then press "ok".
The option to take a spatial subset is available in this box. You can use it if you need before you press "ok".



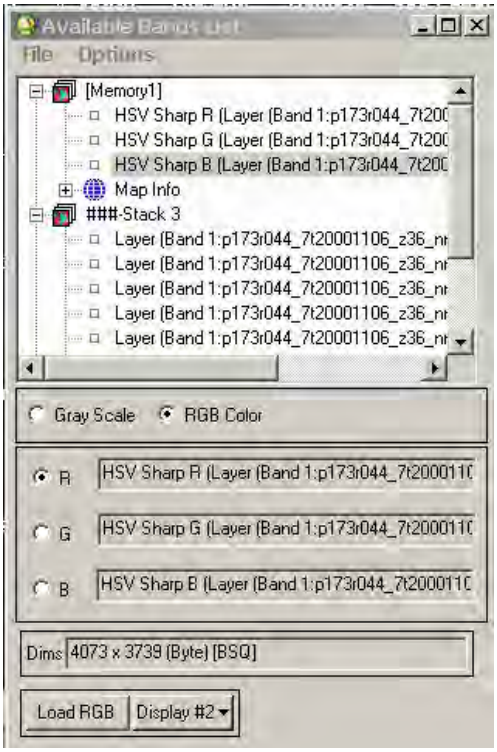
11- The “HSV sharpening Parameters” box appears. Select “Memory”. Press “ok”.



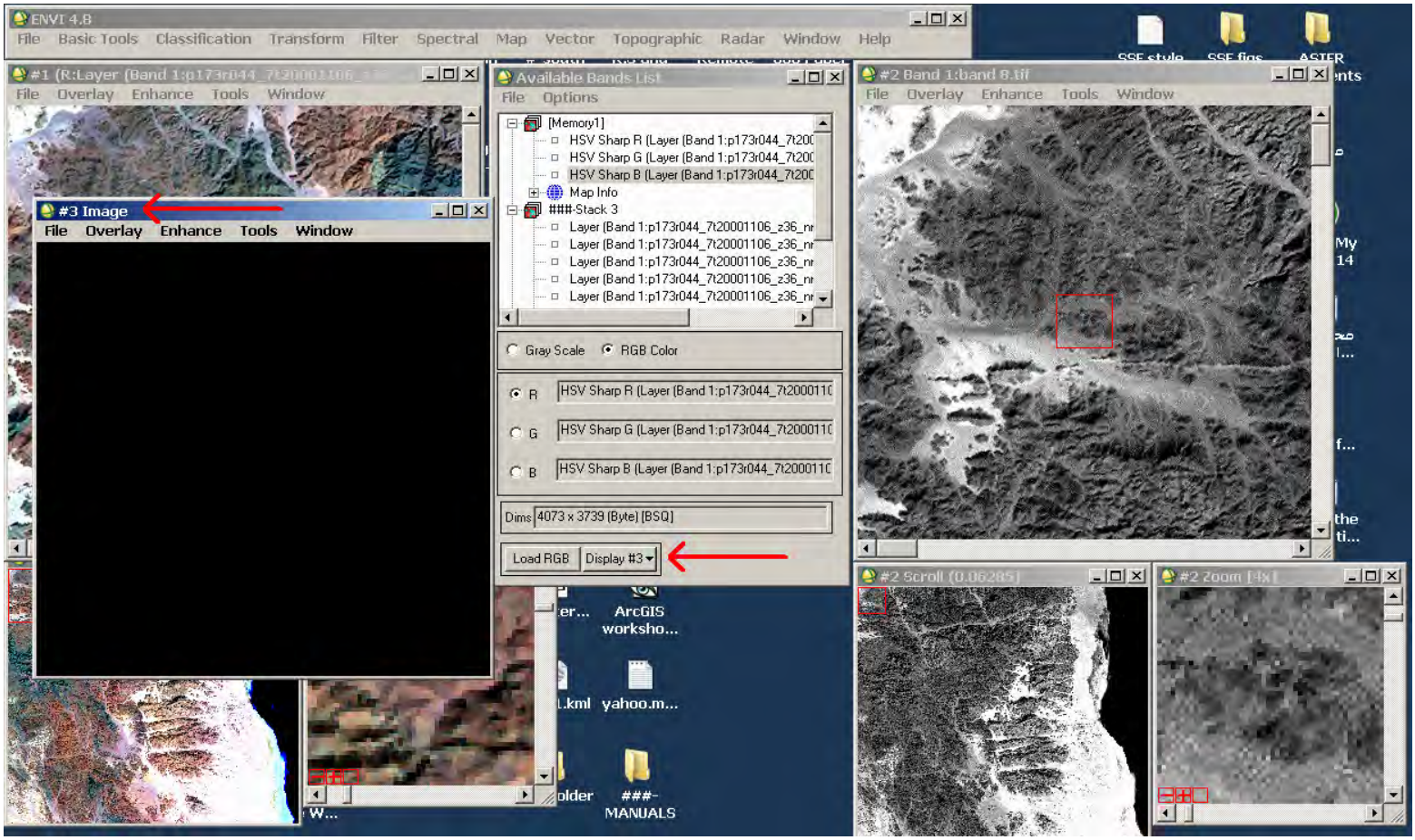
12- In the next box, select “Memory” again. Press “ok”.



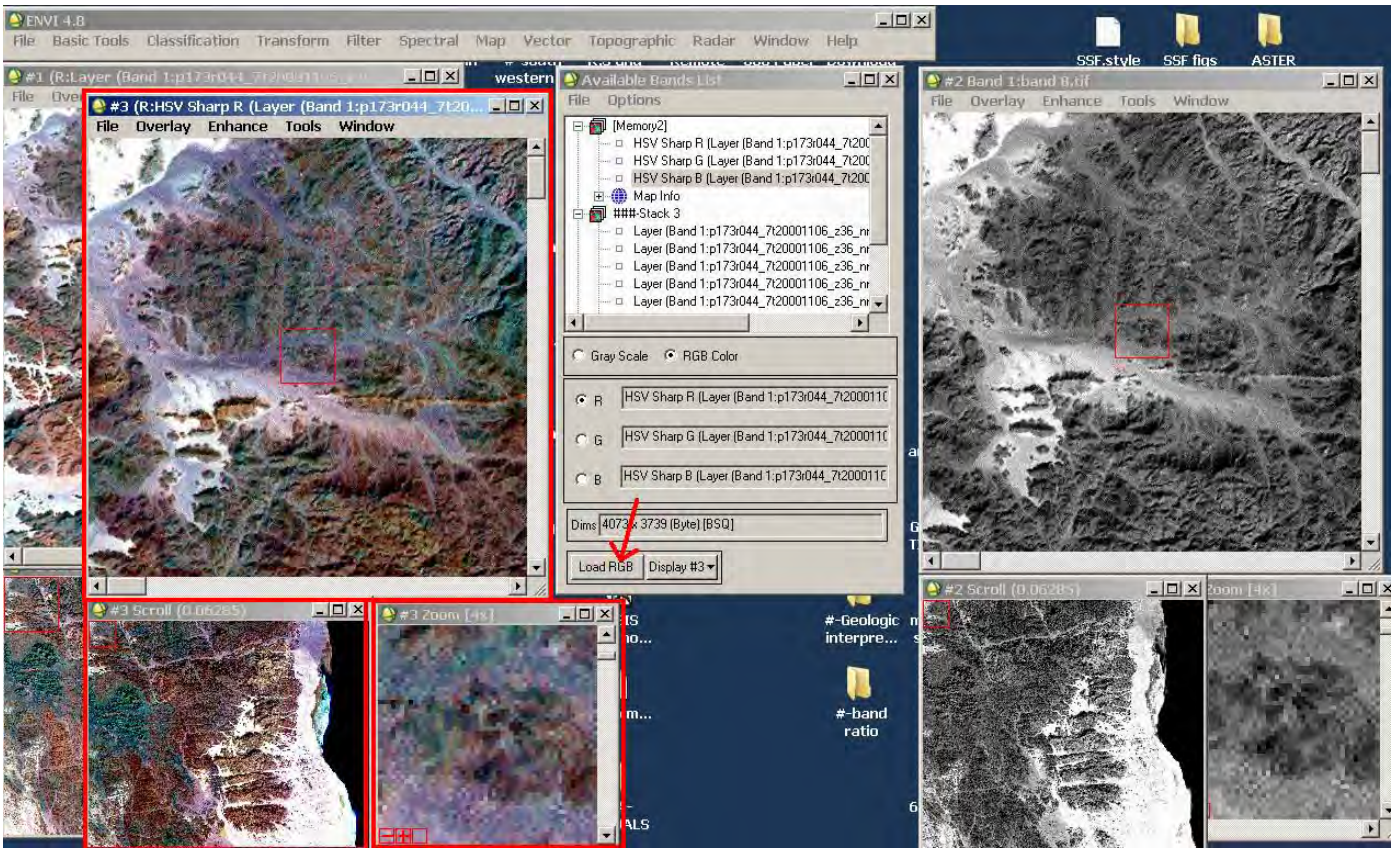
13- In the “Available bands list” box a new layer is added (**Memory 1**) consists of 3 bands. These three bands are automatically loaded as RGB.



14- Open a new blank display (Display #3) to load the result (Memory 1) in it.



15- Press “load RGB”. The new merged image will appear in (Display #3). Make the necessary enhancement.

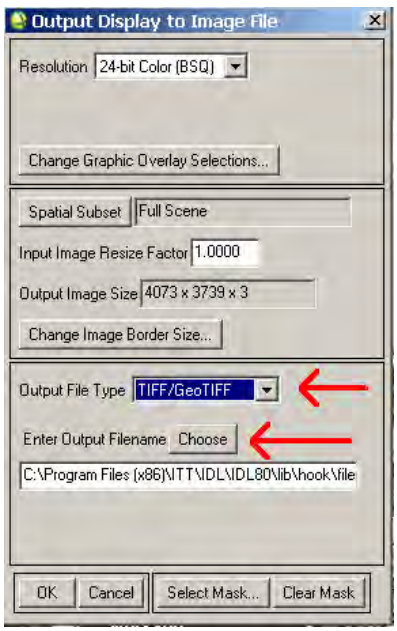


16- If the result is ok, you can save the merged file from the **menu of (Display #3)**.

File / save image as / image file

Choose to save the output file as a tiff file, and choose the location where to save the file. Press “ok”.

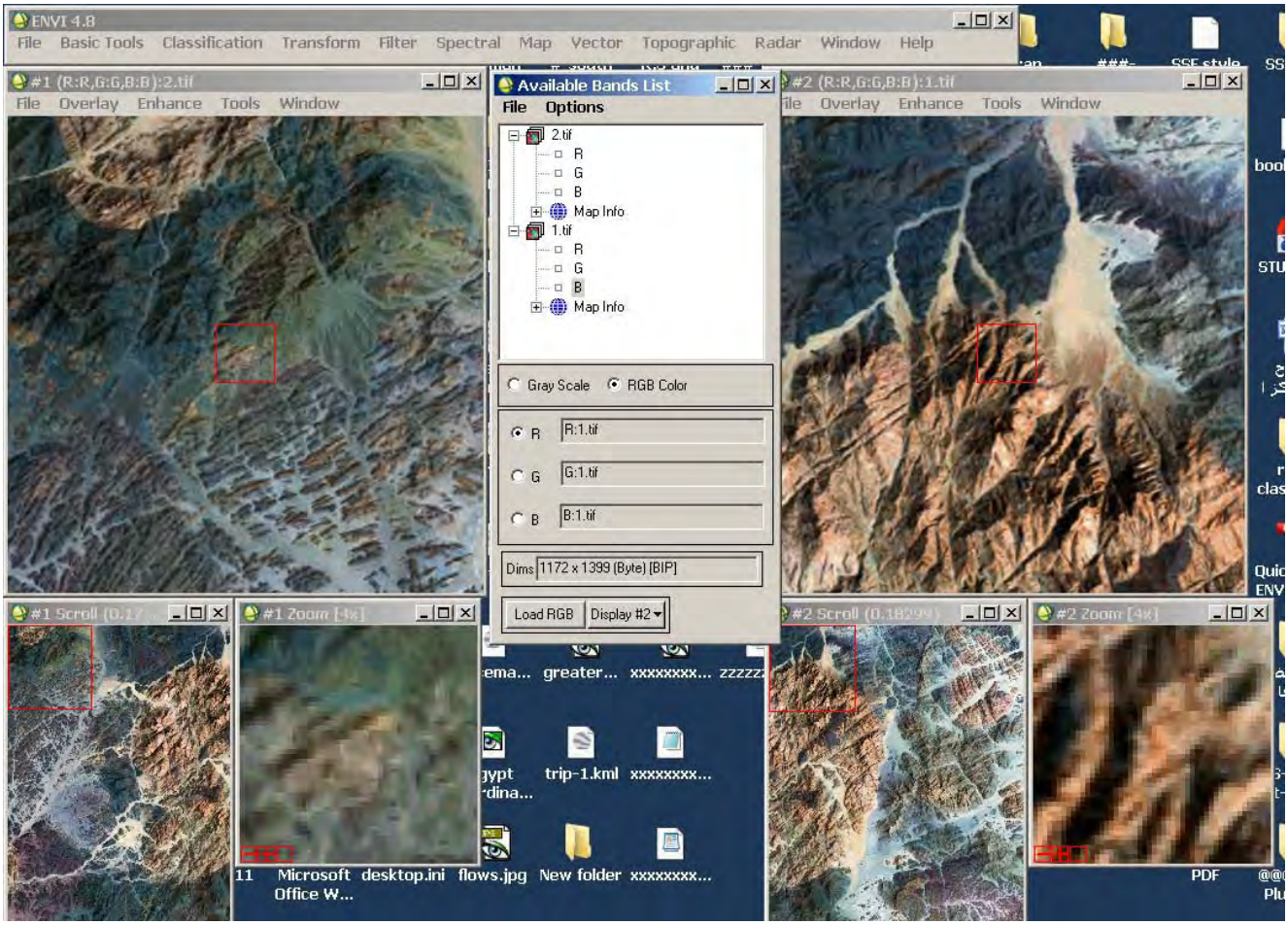
In this box, the option to take a subset is also available for use.



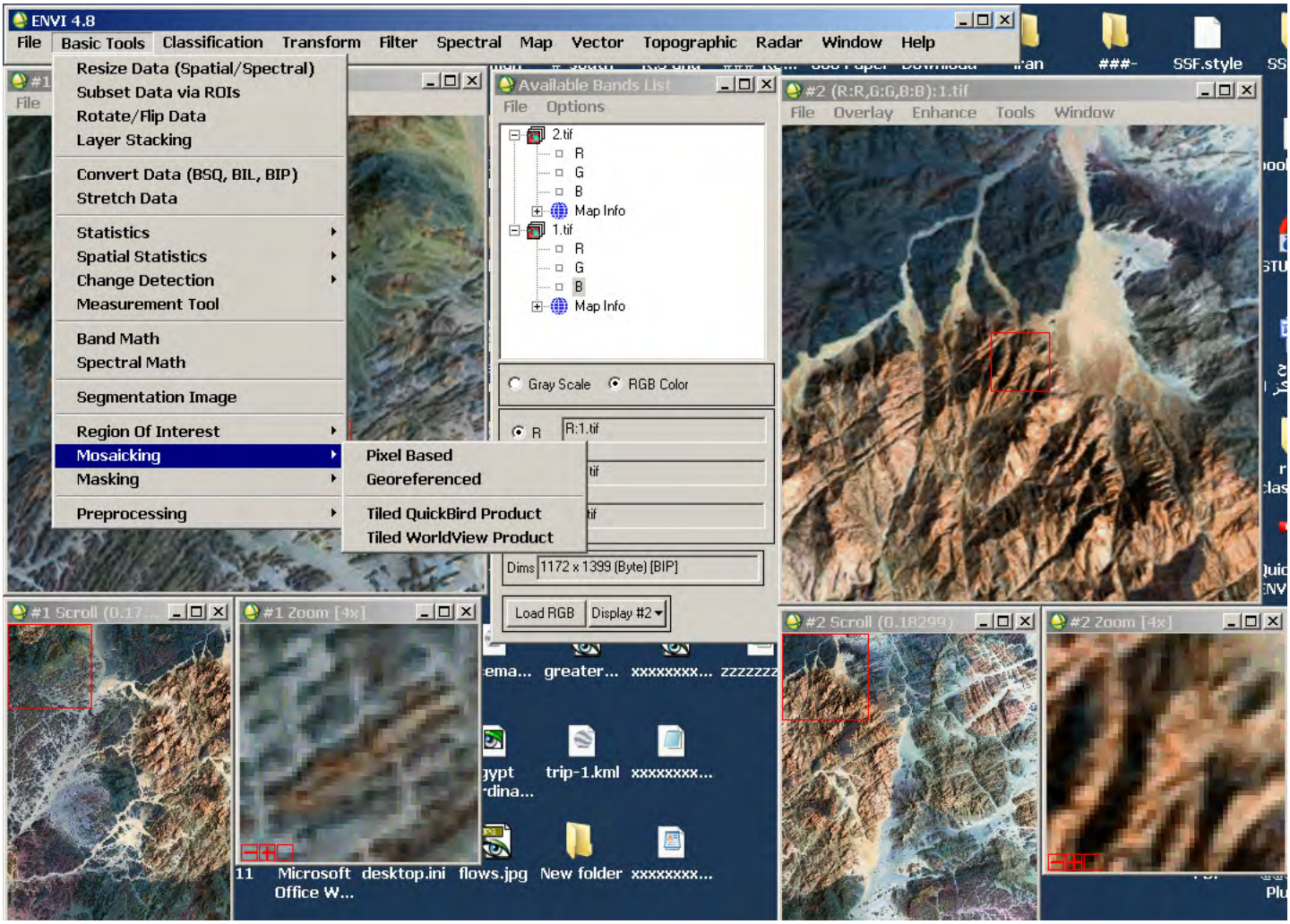
17- Compare the resulted merged file with the 7,4,2 file. You will find that the new image has the same color composite as that of the 7,4,2 file, but has a larger pixel size (i.e. objects are larger in size in the new image)

VII- Mosaicking

1- Open the two images to be mosaicked (image 1.tif and 2.tif) in two separate windows.



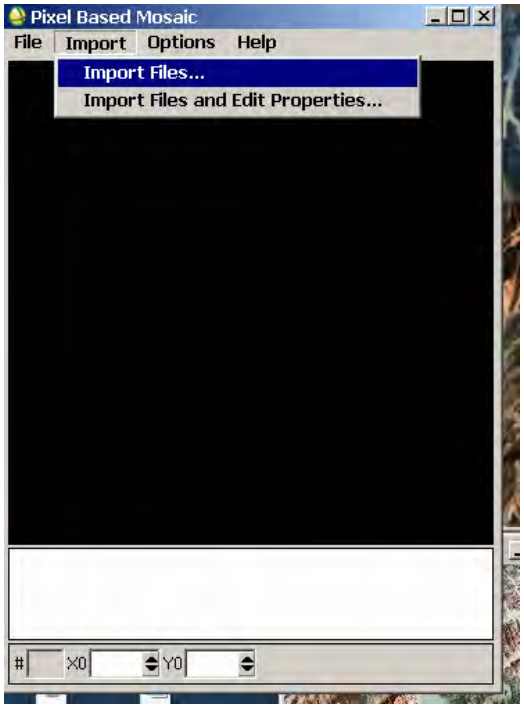
2- From the **main menu** of the program choose “Basic tools/Mosaicking”



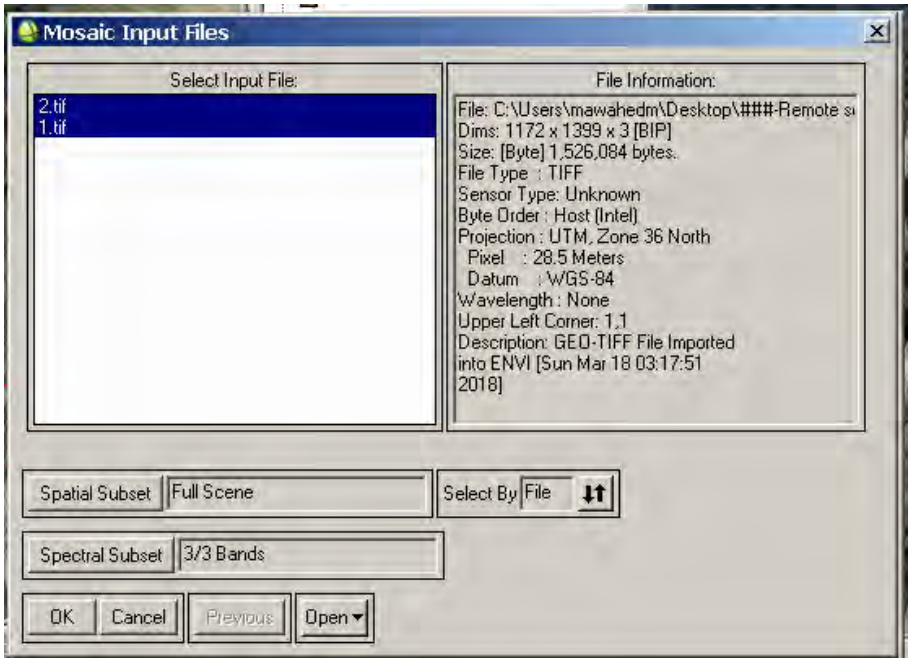
3- Two options for mosaicking appear in the menu of mosaicking:

- **A- <u>Pixel Based</u>** : In this case mosaicking will be done manually.
- **B- <u>Georeferenced</u>** : In this case mosaicking will be done automatically based on the coordinates of the two images.

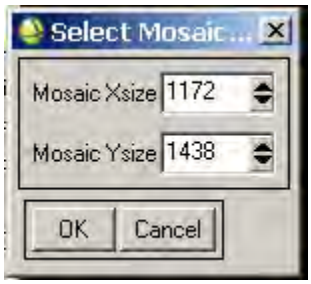
4- To try the first type, Choose **<u>“Pixel based”</u>**. The “pixel based mosaick” dialog box appears. Choose “Import/Import files”



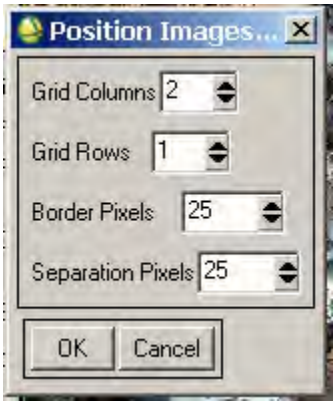
5- The “Mosaic input files” dialog box appears. Highlight (choose) the two files (1.tif and 2.tif), and press “ok”. If you need, you can make a subset from this widow.



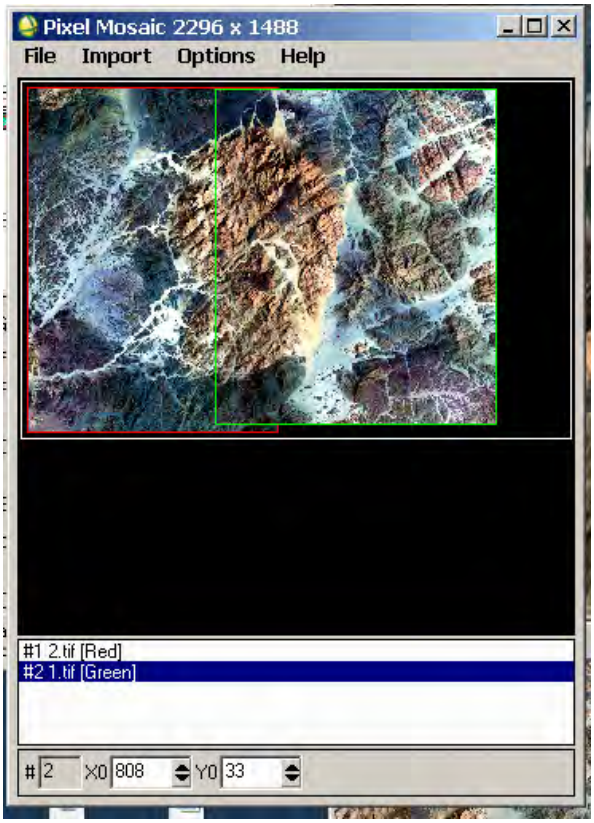
6- The “Select mosaic size” box appears. Leave the parameters as it is, and press “ok”.

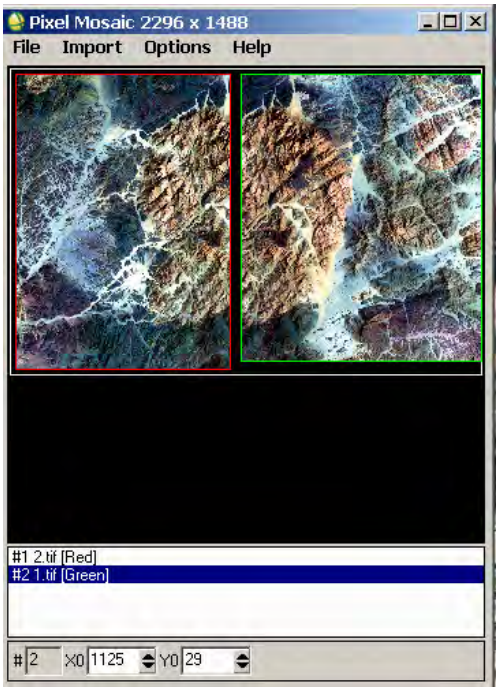


7- The “Pixel mosaic” box appears. Choose “options/position entries into grid”. The “Position images” box appears. In this box you can choose the number of columns and rows suitable for the number of images you will mosaic. In our case: 2 columns and 1 row are ok. Press “ok”.

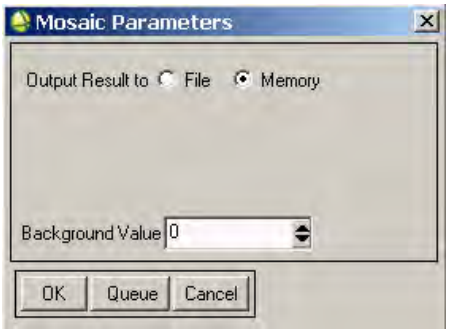


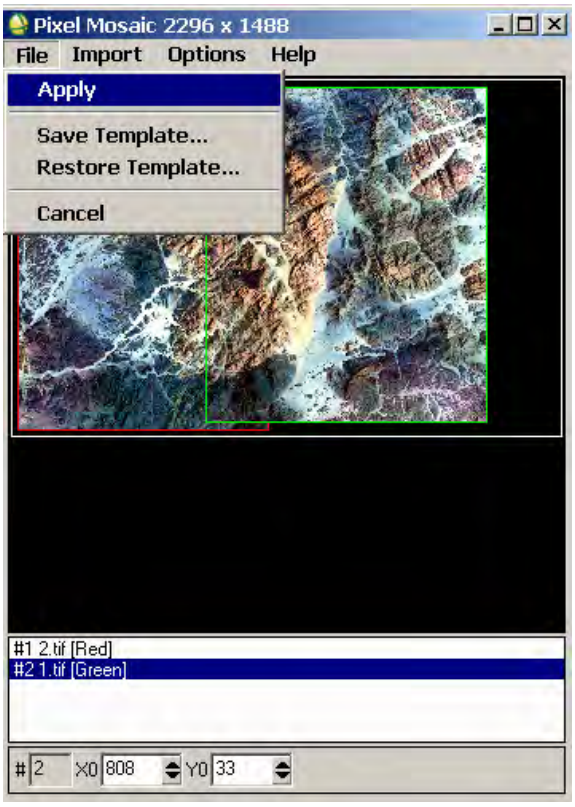
8-The two images will appear together in the mosaicking box. Left click on one of the two images and drag it to the correct position relative to the other image.





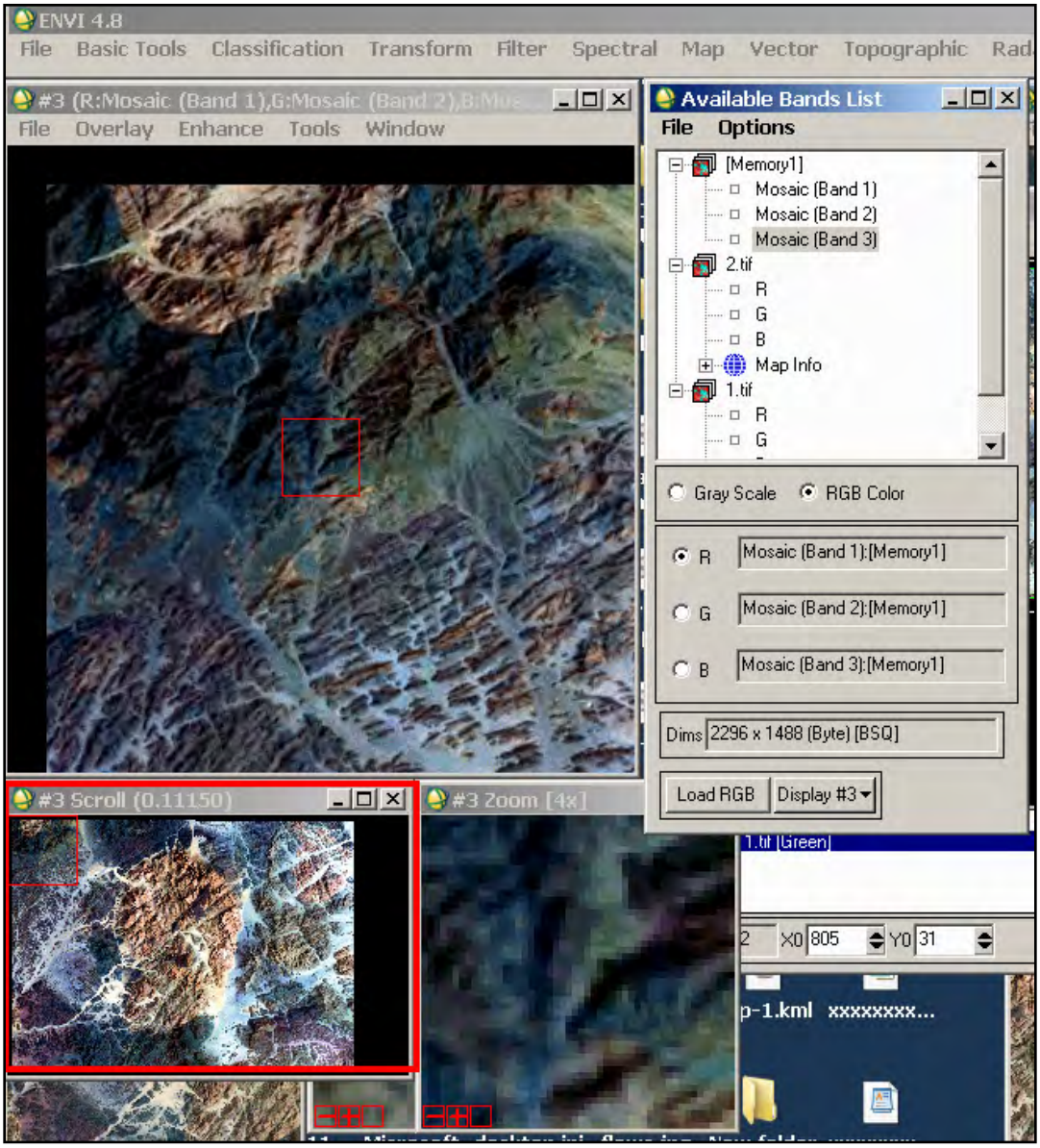
9- Press “File/Apply”. The “Mosaic Parameters” box appears. Choose “Memory” and press ok.



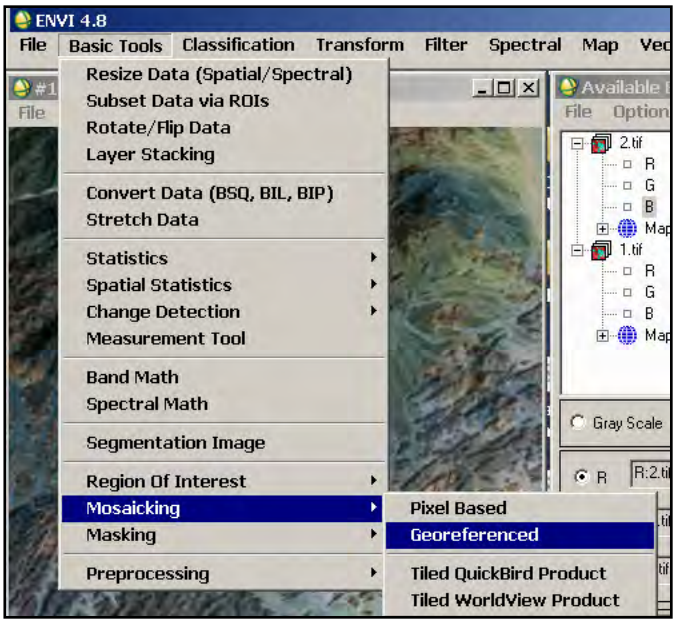


10- The mosaic file will be opened in the “Available band list” box as a memory layer.

11- Open the mosaic in a new display. If it is ok, you can save it.



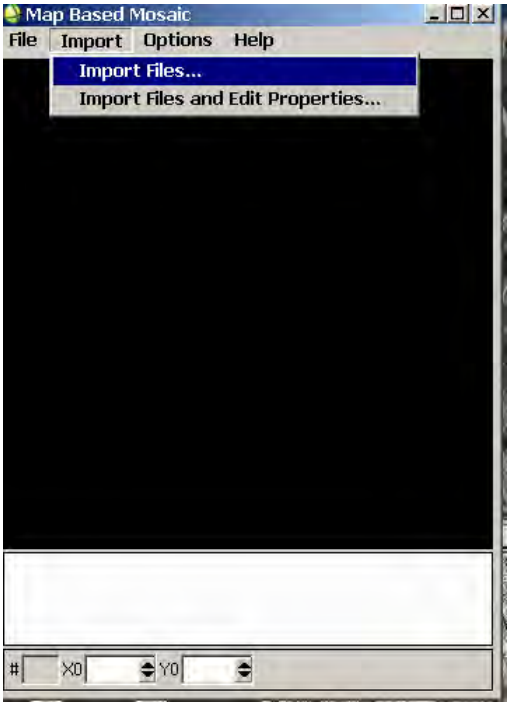
###-<u>Mosaicking using the second option "Georeferenced"</u>



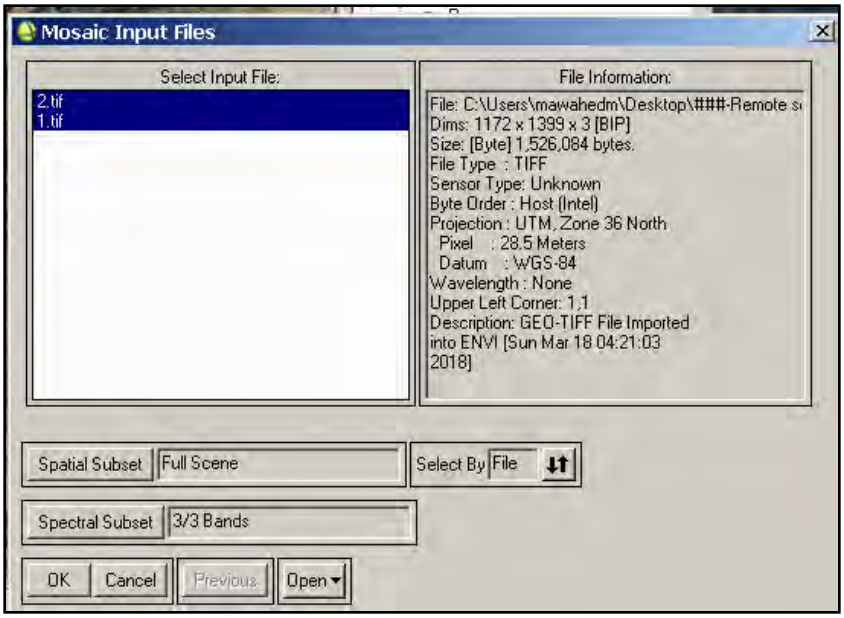
1- Open the two images (1.tif and 2.tif) as described before.

2- Select "Basic tools/mosaicking/Georefernced".

3- The "map based mosaic" box appears. Select "Import/Import files".

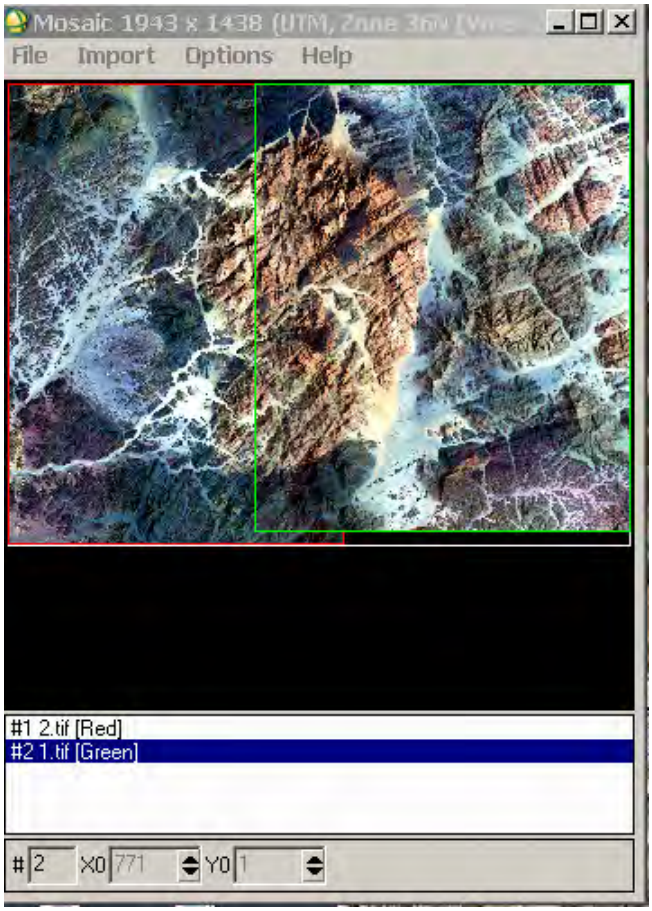


4- The "mosaic input files" box appears. Choose the two file to be mosaiced and press ok. If you need, you can make a subset at this window



5- The two image will be opened and they are mosaiced automatically.

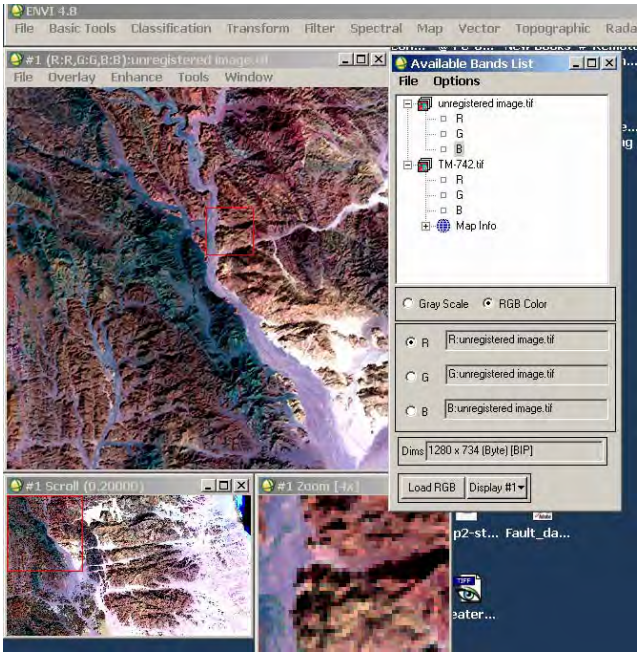
6- Follow the steps 9-11 explained before.



VIII- REGISTRATION (georeferencing-rectification)

The process of registration is to define the coordinates for a satellite image or a map of undefined coordinates (i.e. there is no header file for the image).
There are two methods for registration:

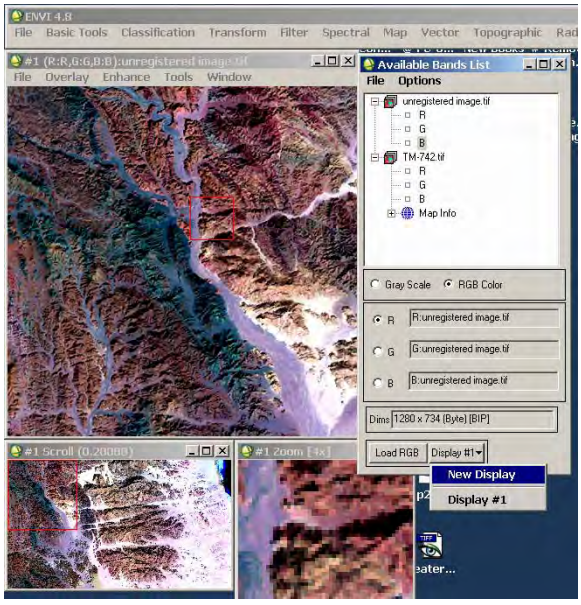
A. Image to image registration: by defining ground control points (GCPs) in the unregistered image and obtaining the coordinates of these points based on the comparison with the registered image or map.
B. Image to map registration: by locating ground control points (GCPs) in the unregistered image where these points have previously known coordinate values. The coordinate values are entered manually to the software.

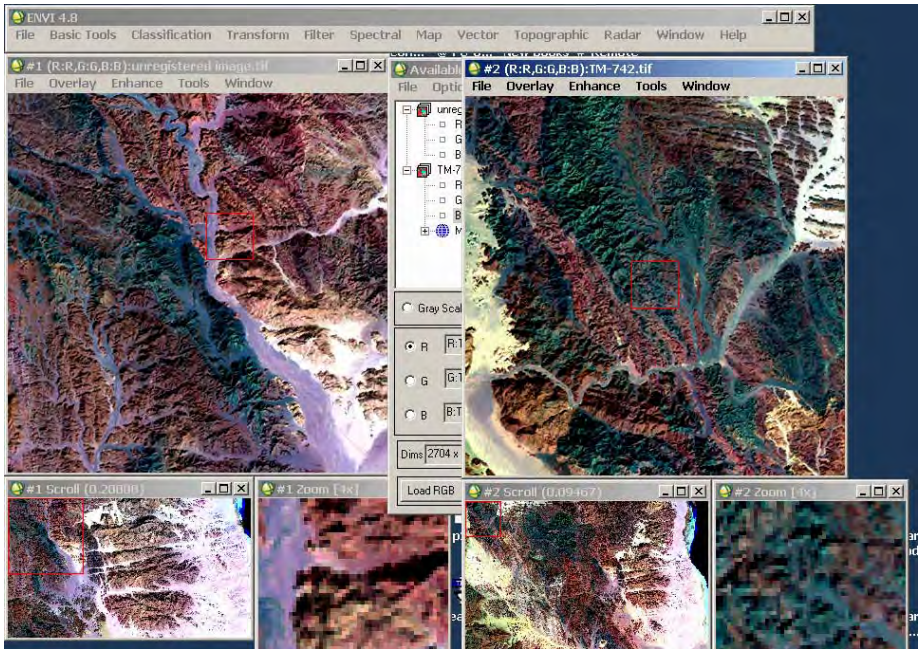


A- Image to image registration:

1- Open the unregistered image (unregistered image.tif) in ENVI .

2- Open a new display and load the registered image (TM-742.tif) in the new display.

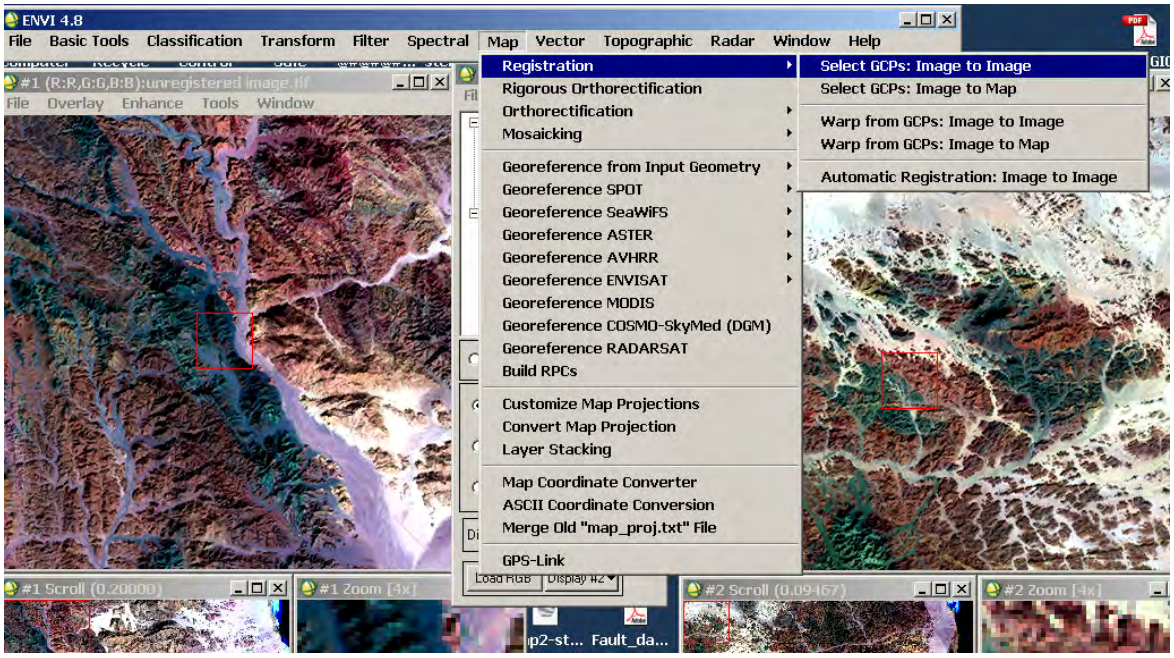




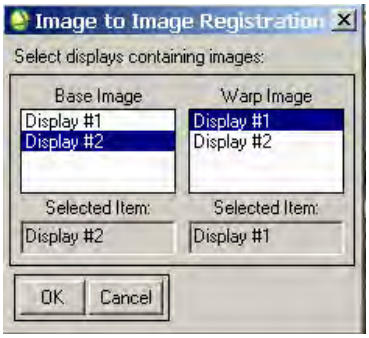
3- Now you have the two images opened in two separate displays.

- **The unregistered image (unregistered image.tif) in display 1.**
- **The registered image (base image-TM-742.tif) in display 2.**

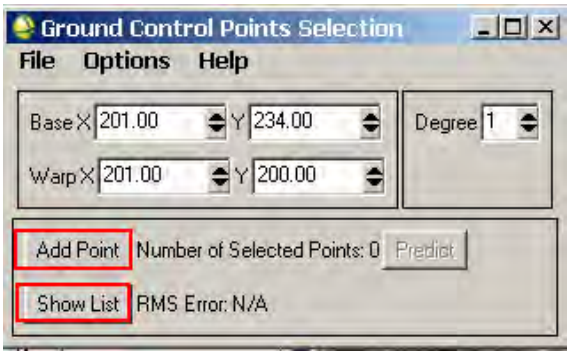
4- From the **main menu** of ENVI, open "Map/Registration/Select GCPs: image to image".



5- The "image to image" box appears. Choose
Display2 for base image (registered image-TM-742.tif)
Display1 for Warp image (unregistered image-unregistered image.tif)
Press "ok". **The displays must be selected correctly; otherwise the whole process will be incorrect**.

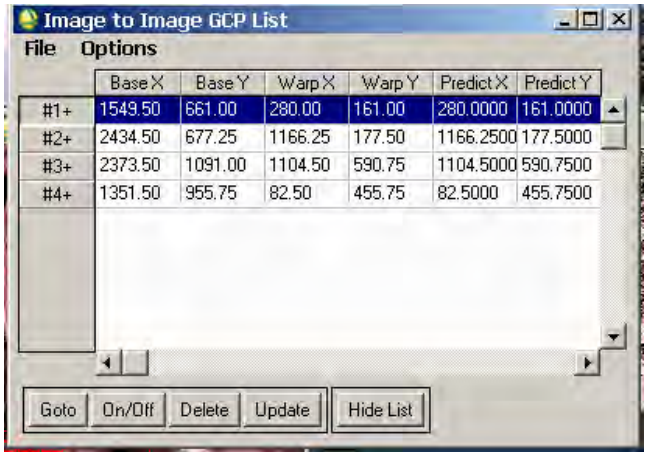


6- The "Ground Control Point Selection" box appears. Press on a point in "display 1" and on the same point in "display 2". The two points will be recorded in the "Ground Control Point Selection" box. Press "add point" button to fix the first (GCP). <u>You can accurately mark the GCPs using the zoom window</u>. In locating the GPSs, there is no problem to start with any of the displays.



7- Repeat the same process to fix **<u>4 control points</u>** at least. After locating each point you must press "add point". The chosen points are better to be away from each other as possible and close to the borders of the image as possible. The greater the number of GCPs, the more accurate will be the registration process.

8- Press “show list” button to see the table of points you added.



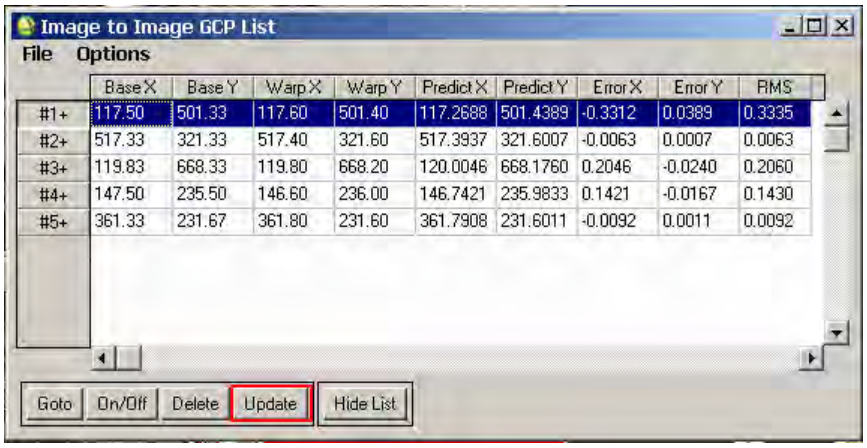
9- In this table **(after the addition of 5 points)** you can see the value of the error in placement of the GCPs. A Point of high error can be corrected as follows:

a- Highlight this point in the list.

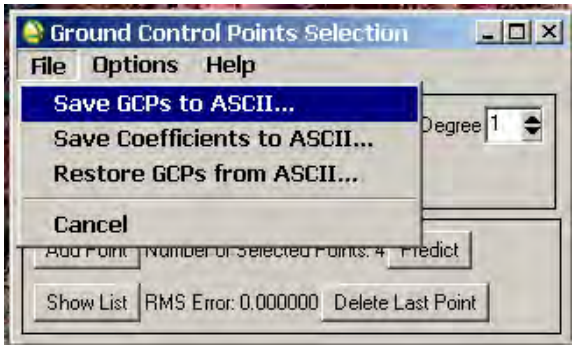
b- Reposition the point in the two images to a more accurate position.

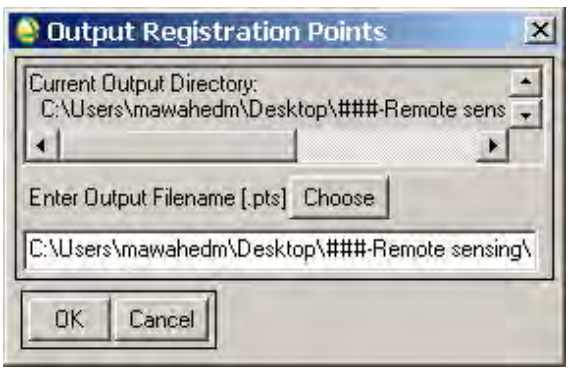
c- Press “update” button to inter the new values for this point.

d- If the error still high the point must be deleted and replaced by a new point.

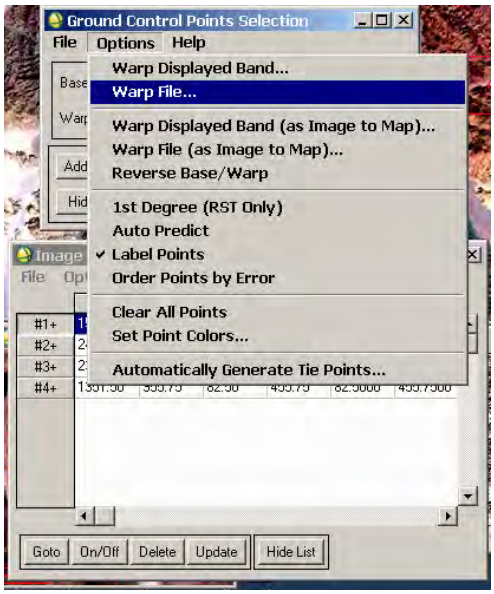


10- If you want to save the data of the control points into a text file (to be used later): in the “Ground control points selection” box, press “File/Save GCPs to ASCII”. The “Output Registration points” box appears. Choose the name and location of the output file.

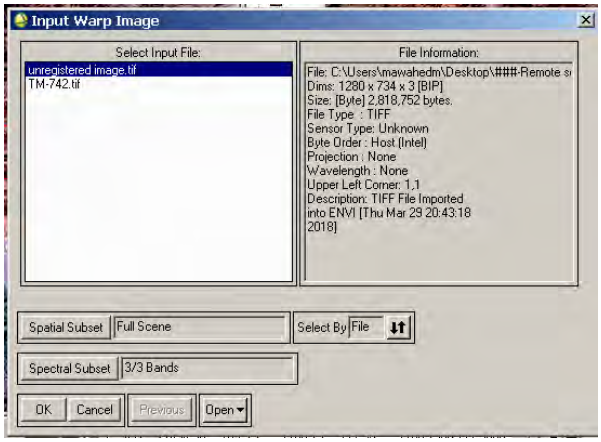




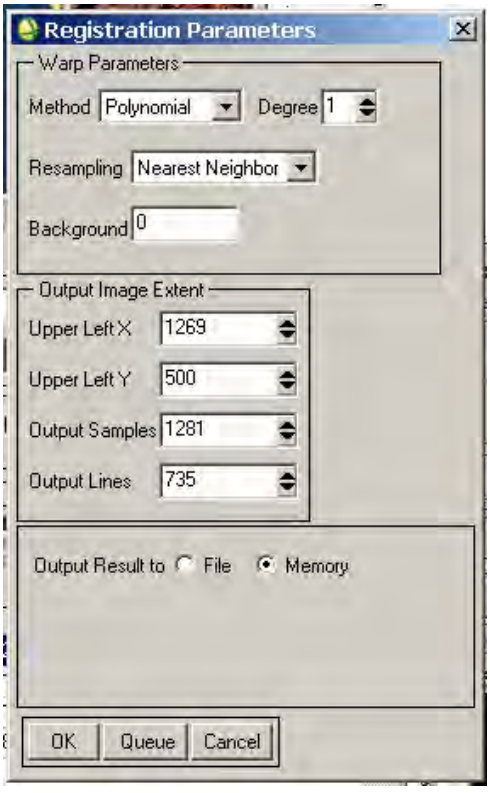
11- To finish the registration process, press “Options/ Warp file”. The “Input Warp image” box appears.

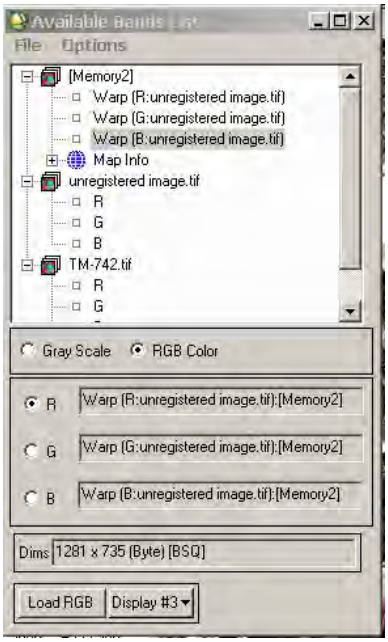


12- Chose the unregistered image as input file, then press “ok” .

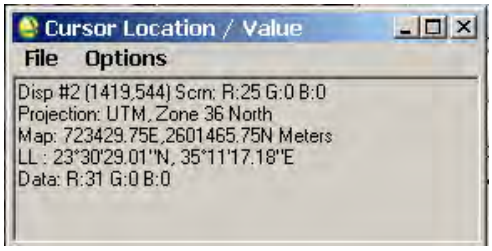


13- The “Registration Parameters” box appears. Select to get the results in memory. The resulted output file will be loaded into the “available band list” box



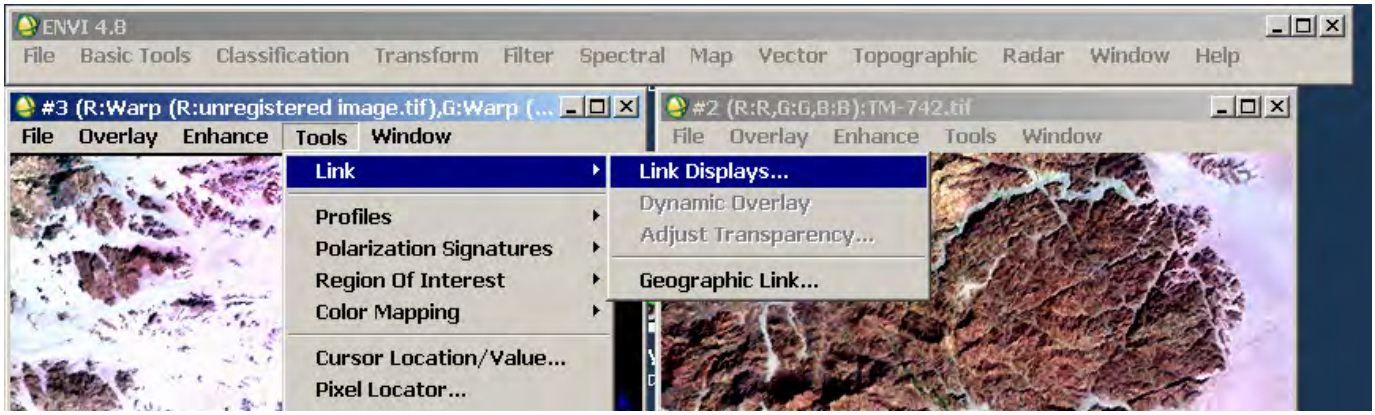


14- Load the Warp file (the resulted file) in a new display(Display 3). Double click on any part of the image window; the “courser location value” box appears. You will find that the image has coordinates and projection.



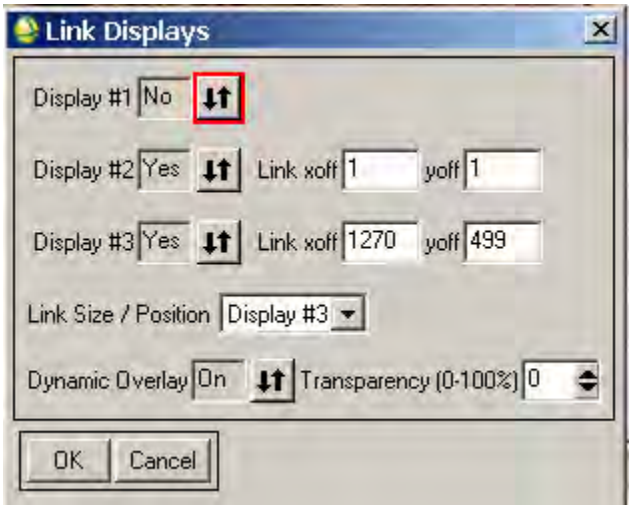
15- To check for the accuracy or validity of the registration process “Link” the warped image to the base image as follows:

a- In Display 3, press “Tools/Link/Link Displays”. The “Link Displays” box appears



b- In this box you want to link the warped image in display 3 and the base image in display 2. So you must cancel the link with display 1 in this box. Press on the button in front of Display 1 to make the selection “NO”. Press “ok”.

c- Now, the two displays are linked together. If the registration process is ok, by pressing at any point in Display 3, the same point will appear in Display 2. In this way you can compare the two images.



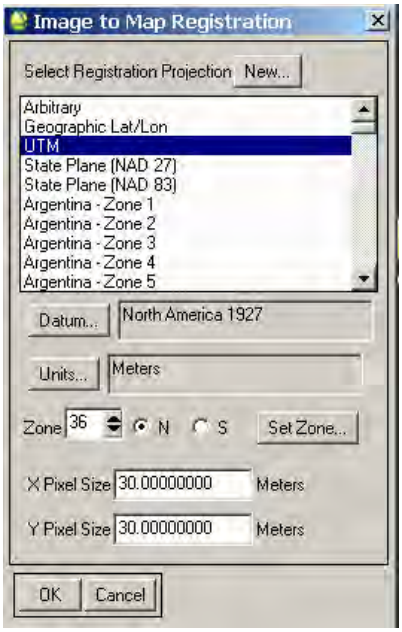
16 -If the results are ok, you can save your results from the last opened display (Display 3)

B- Image to map registration:

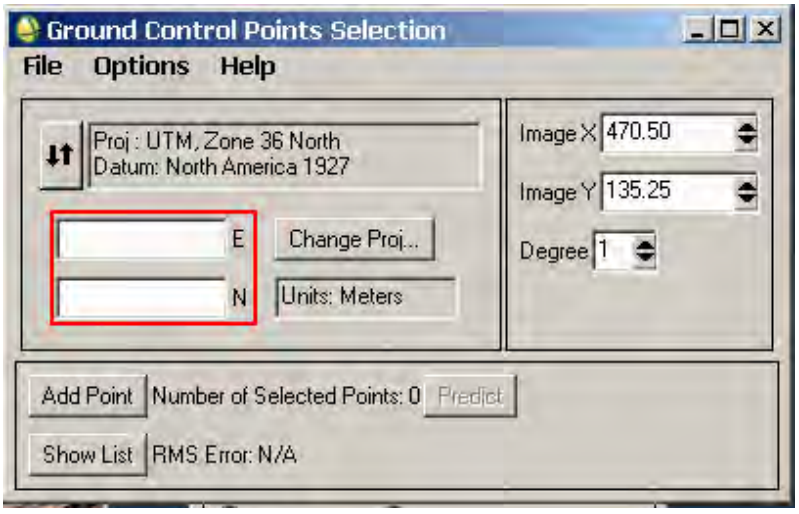
In this method you must have the coordinates of (at least) 4 GCPs. The coordinate values will be given to the software to be used in the registration process.

1- Open the unregistered image (unregistered image.tif) in ENVI . Open "Map/Registration/Select GCPs: image to map".

2- The "Image to map registration" box appears, in which you must defined the coordinate system of the GCPs that will be given to the software. Press "ok".

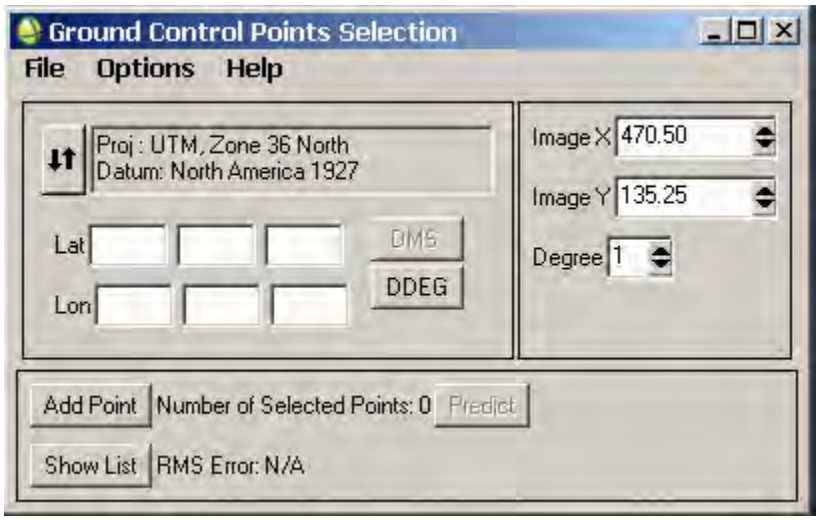


3- The "Ground control points selection" box appears.



4- Mark the position of the control point on the image, and then enter its coordinates in the box manually.

4- If the coordinate values to be entered are in geographic coordinates, use the Button  to change the style of data input



5- Enter the coordinates of at least 4 GCPs.

6- To complete the registration process, follow the steps from 9 to 16 mentioned in the previous section.

IX- Image classification

- **Data clustering** is a mathematical process of classification of any type of data into classes; the data in each class are equal or close together in their value.
- **Image classification (spectral clustering)** is classifying pixels of a multispectral image into discrete classes based on the value of pixel reflectance or digital number (DN).
- There are two main basis of image classification. The first is based on statistical methodology only. The second is based on user-defined training classes (user-defined small areas defined by the user and used by the software as a base for classification).
- **Unsupervised** classification is used to cluster pixels in a dataset (image) based on **statistics only**, without any user-defined training classes. Two unsupervised classification techniques are available:

    1- ISODATA Classification.

    2- K-Means Classification.

- **Supervised** classification is used to cluster pixels in a dataset (image) into classes based on user-defined **training classes (region of interest, RIO)**. Some popular supervised classification methods available in ENVI are:

    1- Parallelepiped Classification.

    2- Minimum Distance Classification.

    3- Mahalanobis Distance Classification.

    4- Maximum Likelihood Classification.

    5- Binary Encoding Classification.

    6- Spectral Angle Mapper Classification.

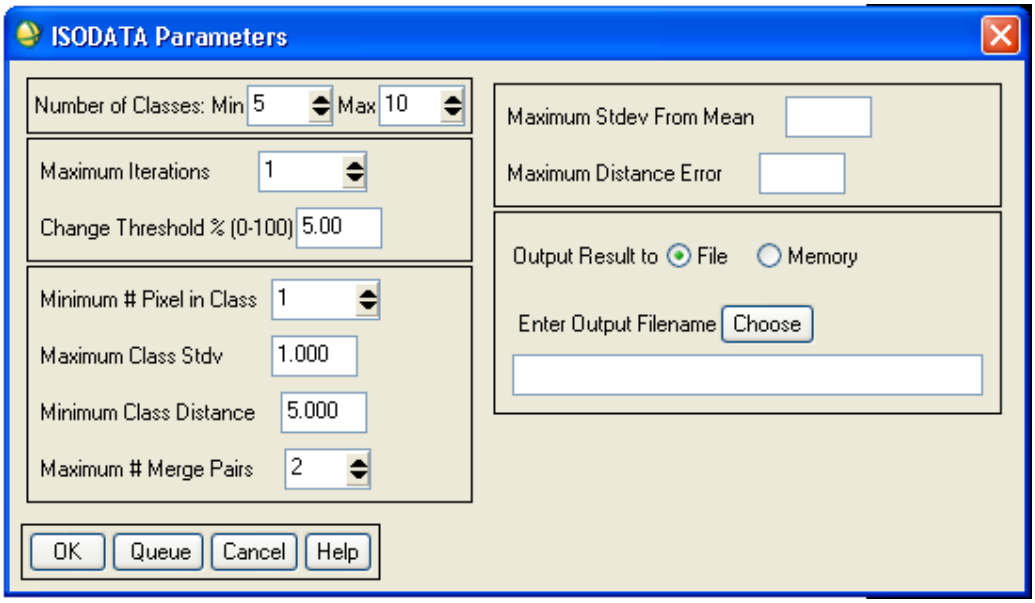
    7- Spectral Information Divergence Classification.

- Some of these supervised classification methods (no.1, 2, 3, 4, 5) are based on the **training classes (region of interest, RIO)**. The difference between them is the algorithm used in the clustering calculation. Methods (6, 7) are based on what is known as **"spectral library"**. These libraries are available in ENVI and represent the reflectance of minerals, rocks or vegetation types that can be used for minerals, rocks, or vegetation detection and classification.

IX-A- Unsupervised Classification

A- Using ISODATA Classification

1. From the ENVI main menu bar, open the original image to be classified.
2. From the ENVI main menu bar, select **Classification → Unsupervised → IsoData**. The Input File dialog appears.
3. Select an input file (the image to be classified), then click **OK**. The ISODATA Parameters dialog appears.
4. Enter the minimum and maximum **Number of Classes** you want. ENVI uses a range for the number of classes because the ISODATA algorithm splits and merges classes based on input thresholds and does not keep a fixed number of classes.



5. Enter the maximum number of iterations in the **Maximum Iterations** field and a change threshold (0-100%) in the **Change Threshold %** field.

   Iteration is the repetition of the classification process to improve the mean value of each class and class limits. **Threshold** is the number of pixels (in percent) below which the classification process stops. It means that the clustering process ends when the number of pixels in each class changes by a percent less than the threshold value. ENVI uses the change threshold to end the iterative process when the number of pixels in each class changes by less than the threshold. The classification ends when either this threshold is met or the maximum number of iterations is reached.

6. Enter the minimum number of pixels needed to form a class in the **Minimum # Pixels in Class** field. If there are fewer than the minimum number of pixels in a class then ENVI deletes that class and the pixels placed in the class(es) nearest to them.
7. Enter the maximum class standard deviation (in DN) in the **Maximum Class Stdv** field. If the standard deviation of a class is larger than the defined standard deviation then the class is split into two classes.

8. Enter the **minimum class distance** (in DN) between class means and the **maximum number of merge pairs** in the fields provided.

   If the distance between class means is less than the minimum value entered, then ENVI merges the classes. The maximum number of class pairs to merge is set by the maximum number of merge pairs parameter.

   To set the optional standard deviation to use around the class mean and/or the maximum allowable distance error (in DN), enter the values in the **Maximum Stdev From Mean** or **Maximum Distance Error** fields, respectively.

   If you enter values for both of these optional parameters, the classification uses the smaller of the two to determine which pixels to classify. If you do not enter a value for either parameter, then all pixels are classified.

9. Select output to **File** or **Memory**.

10. Click **OK**. The status bar cycles from 0 to 100% for each iteration of the classifier. ENVI adds the resulting output to the **Available Bands List**.

11. To display the resulted classification load the classification image in a new display using the "grey scale" option.

B- Using K-Means Classification

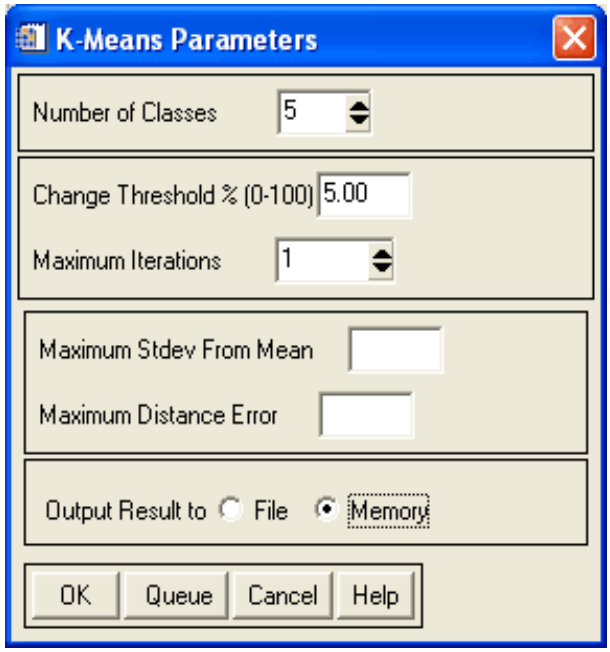
Practically, the steps used to carry out the K-mean classification in ENVI are similar to the isodata classification. The only difference is that the number classes is given a fixed value determined by the user. The number of classes in the isodata classification is a range between a minimum and maximum values determined by the user.

In both types of unsupervised classification methods, do the following:

1- Use the maximum iteration = 1 (the default value), and get the classified image.

2- Use the maximum iteration = 5 and get the classified image.

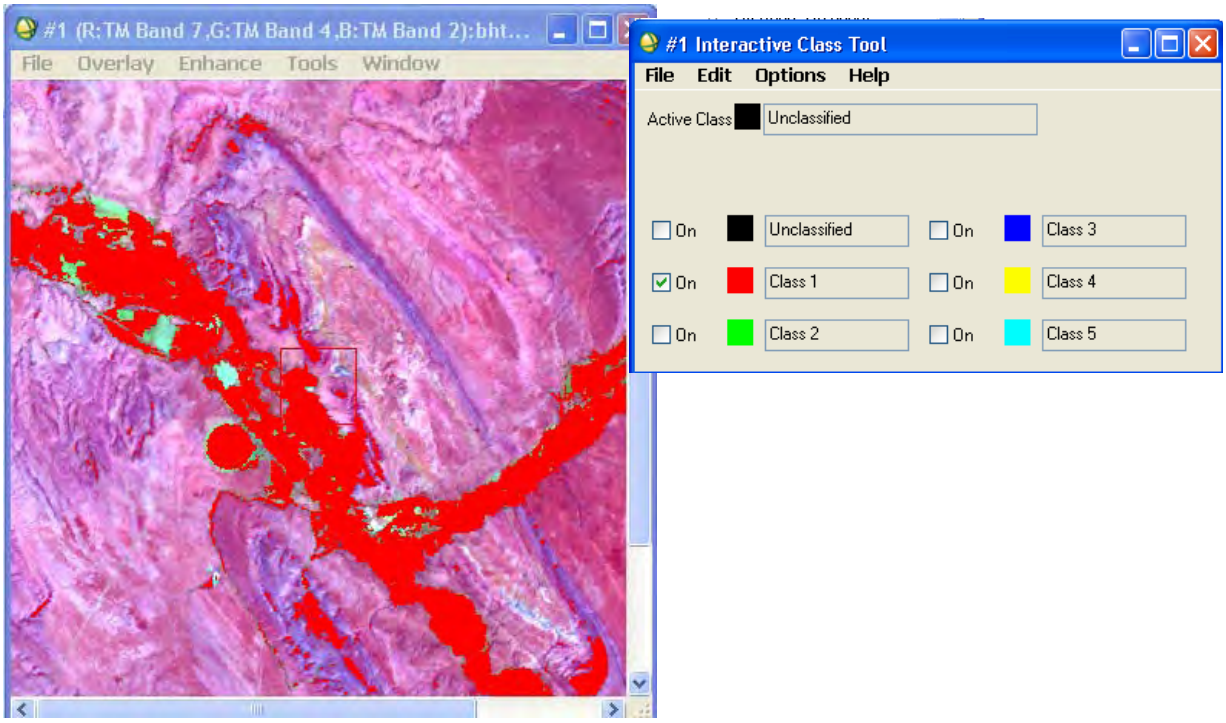
3- Notice the difference between the two cases.



Overlaying the classified classes on the original image, Edit class names and colors, and Merging classified classes:

You can to interactively overlay classes on and off on the displayed image:

1. From the Available Bands List, load the **original image** as a gray scale image or multispectral image.
2. From the Display group menu bar, select **Overlay** → **Classification**. The Interactive Class Tool Input File dialog appears.
3. Select the **classified image** file within the "Select Input File section" of this dialog and click **OK**. The Interactive Class Tool appears with each class listed with its corresponding colors.



4. Click each **On** check box to change the display of each class as an overlay on the original image.

5- To edit the class name or color use Options → **Edit class colors / names.**

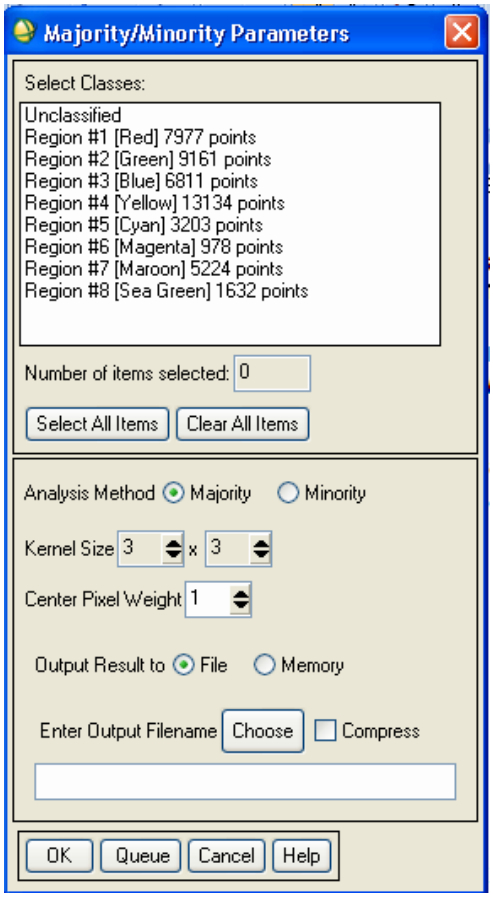
6- To merge two classes or more use Options → **Merge classes.**

7. From the Display group menu bar, select **File** → **Save Image As** → **Image File** to burn in the classes and output to a new file.
8. From the Interactive Class Tool menu bar, select **File** → **Cancel** to exit the interactive tool.

Improving and smoothing the classified image (solve the problem of isolated pixels occurring in other larger classes.):

There are several methods to solve this problem. Some methods consider the isolated pixels as unclassified and others add them to the surrounding class. The most popular method is the **"majority/minority analysis" technique.**

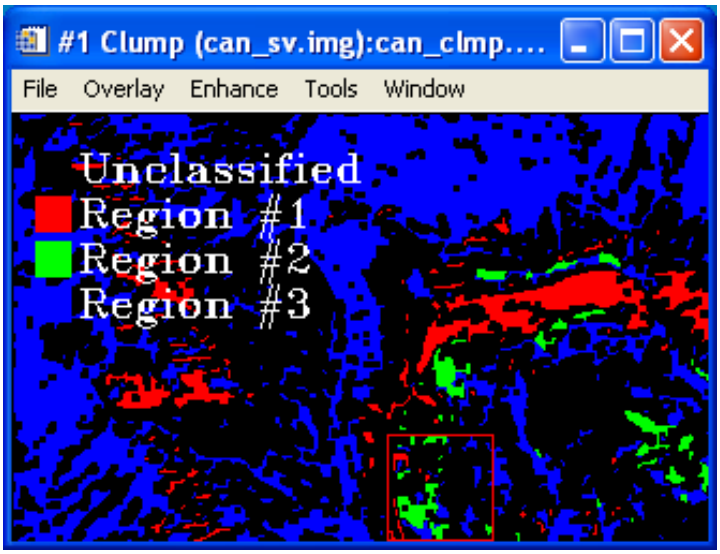
1. From the ENVI main menu bar, select **Classification → Post Classification → Majority/Minority Analysis**. The Input File dialog appears.
2. Select the classification image file, then click **OK**. The Majority/Minority Parameters dialog appears.
3. In the list of classes, select the classes that you want to apply the analysis to. If the problem of isolated pixels is found in all classes, choose all classes.
4. Select the analysis method, by clicking the corresponding toggle button. Choose **"majority".**
5. Enter a kernel size. Larger kernel sizes produce more smoothing of the classification image.
6. Select output to **File** or **Memory**.
7. Click **OK**. ENVI adds the resulting output to the **Available Bands List**..
8. Notice if the smoothing process is ok. If not, repeat the process with a higher kernel value.



Adding Classification Keys (legend) Using Annotation

ENVI provides annotation tools to put classification keys (legend) on images and in map layouts. The classification keys are automatically generated.

1. From the Display group menu bar of the classified image, select **Overlay** → **Annotation**.
2. From the Annotation menu bar, select **Object** → **Map Key** to start annotating the image. You can edit the legend characteristics by clicking the **Edit Map Key Items** button in the dialog and changing the desired characteristics.
3. Click once with the left mouse button in the Image window to place the legend in the image window.
4. Click and drag the legend using the left mouse button in the display to place the key.
5. Click in the display with the right mouse button to finalize the position of the legend.



IX-B- Supervised classification

Supervised classification is based on training classes (Regions of interest, ROI) defined by the user. You must prepare the Regions of interest (ROI) before performing supervised classification. Each training class (ROI) will represent a certain rock unit.

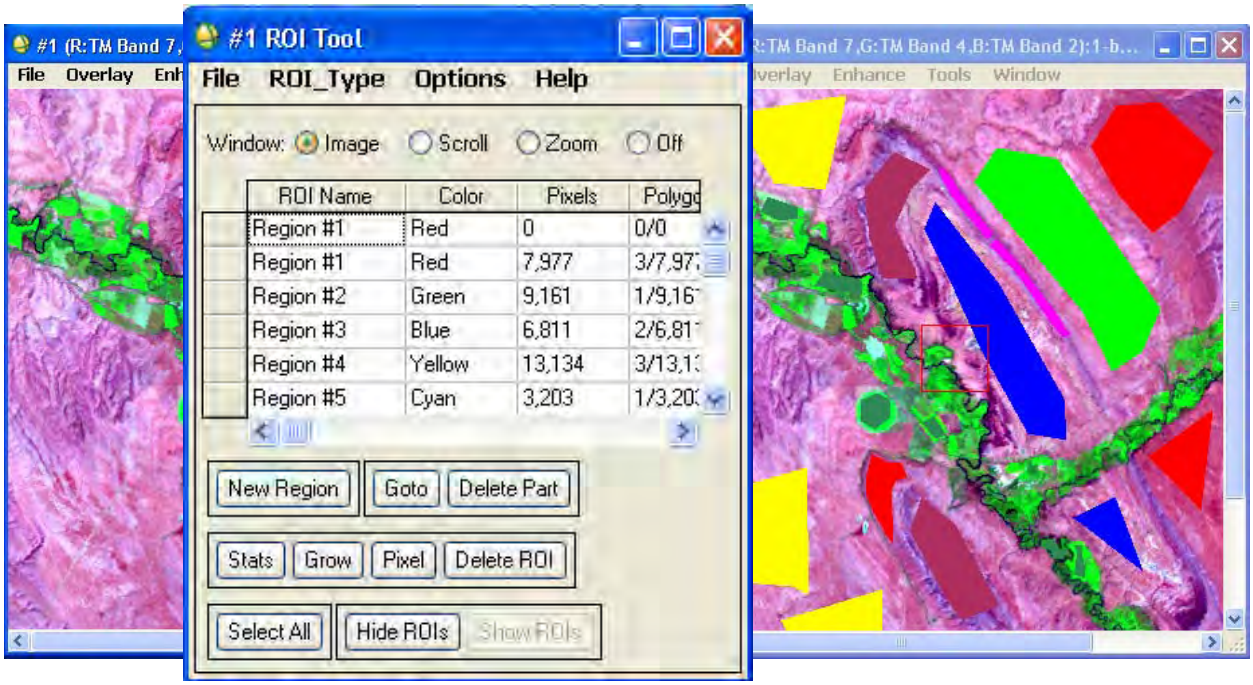
There are many methods for supervised classification. For training, you well apply two types ::

1- Parallelepiped Classification.

2- Mahalanobis Distance Classification.

Carryout both classifications and notice the difference in the produced classified images

A- Defining Training Classes (Region of interest, ROI)



To draw an ROI:

1. Open the original image file in ENVI as usual.
2. Open the **ROI tool** from any of the following locations:

- From the Display group menu bar, select **Overlay → Region of Interest**.
- From the Display group menu bar, select **Tools → Region of Interest → ROI Tool**.
- From the ENVI main menu bar, **Basic Tools → Region of Interest → ROI Tool**.

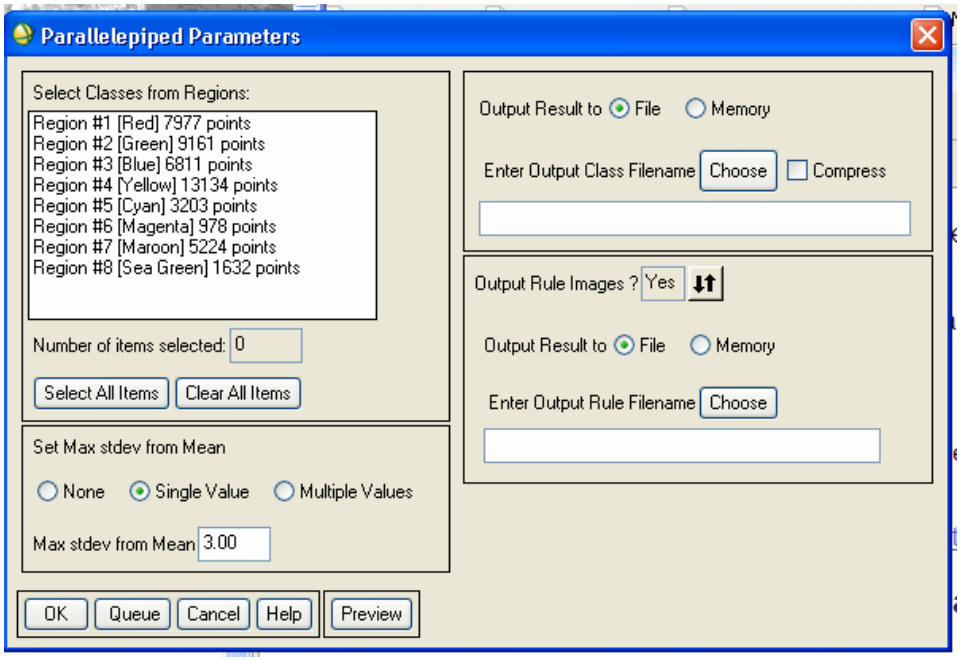
The ROI Tool dialog appears.

3. Select whether to use the **Image**, **Scroll**, or **Zoom** window to draw the ROIs.
4. From the ROI Tool dialog menu bar, select **ROI_Type** to choose the type of the shape you want to draw. Select one of the following options: **Polygon, Polyline, Point, Rectangle,** or **Ellipse.**

5. Move your mouse to the window you have chosen in step 3, and left click on the image to draw your shape. After drawing the shape right click once to close the shape, and right click a second time to fix the shape. You can draw several shapes in the same class. The class name and color are defined automatically, that can be changed later by editing as explained before in the previous lab..
6. To create a new class (region), press "**New Region"** button, and draw your new shapes. You can create new classes as many times as you want.
7. To delete a class (region), select that class in the classes list (in the ROI column) and press the button "**delete ROI**".
8. To delete a part of the class, select the class in the classes list and press "**goto**" button several times to locate the shape you want to delete. In the image window, a rectangle appears on the shape to be deleted and moved to another shape each time you press "goto". After locating the shape to be deleted press the "**delete part**." Button.
9. To merge two or more classes (regions) into one class, select **Options** → **Merge Regions**. The Merge ROIs dialog appears with two lists of all defined regions.
   a- Under **Choose Base ROI to Merge**, select the name of the base class (the class where other classes will be merged on).
   b- Under the **Choose ROIs to Merge** list, select the names of the classes to merge into the base class.
   c- To remove the original individual classes being merged after they are merged Click the **Delete Merged ROIs?.** The color of the other ROIs change to that of the base ROI and the other names are removed from the ROI Tools dialog table.
   D- Click **OK**.
10. After you finished the plotting of classes, save the training classes into a ROI file from the RIO Tool menu File→ save RIOs.

B- Applying Parallelepiped Classification

1. From the ENVI main menu bar, select **Classification** → **Supervised** → **Parallelpiped**. The Input File dialog appears.
2. Select an image file to be classified then click **OK**. The Parallelepiped Parameters dialog appears.
3. If an error message appears "**there are no ROIs associated with this input file to classify with**", this indicates that the ROI file is not recognized. Press the **open** button (at the lower part of the dialog box), → **ROI File,** and then select the ROI file you previously prepared, press open then ok. Now you can select the image file to be classified again and the Parallelepiped Parameters dialog appears.



4. In the **Select Classes from Regions** list, select any number of classes or all classes as training classes. The ROIs listed are derived from the available ROIs in the ROI file.
5. Select one of the following thresholding options from the **Set Max stdev from Mean** area:
   - **None**: Use no standard deviation threshold.
   - **Single Value**: Use a single threshold for all classes. Enter a value in the **Max stdev from Mean** field to designate the value of standard deviations to use around the mean.
   - **Multiple Values**: Enter a different threshold for each class. **Do not use this option at the present time**.
6. Select classification output to **File** or **Memory**.

7. The **Output Rule Images?** option: if enabled an intermediate file (rule image file) is produced in the “available band list”. This file can be used in post classification processes. **Do not enable this option at the present time.**

8. Click **Preview** to see a classification image before getting a final product. You can change the parameters as needed and click **Preview** again to update the display.

9. Click **OK**. ENVI adds the resulting output classified image to the “Available Bands List”. To view the resulted image, view it in a new display on the “grey scale” option.

C- Applying Mahalanobis Distance Classification

1. From the ENVI main menu bar, select **Classification** → **Supervised** → **Mahalanobis Distance**.The Input File dialog appears.

2. Follow the same steps used in the previous classification. Do not put a value for the “**maximum distance error**”, unless you are not convinced with the resulting classified image.