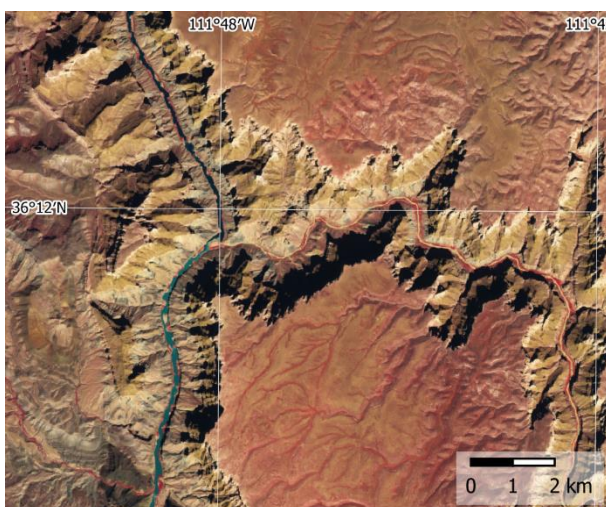


*True colour overview satellite map of the Grand Canyon [Sentinel-2, 2023-09-24].  
Red line [A-D]: position of the elevation profile given below.*



*Confluence of the Little Colorado into the Colorado River [false colour infrared, Sentinel-2, 2023-09-24].*

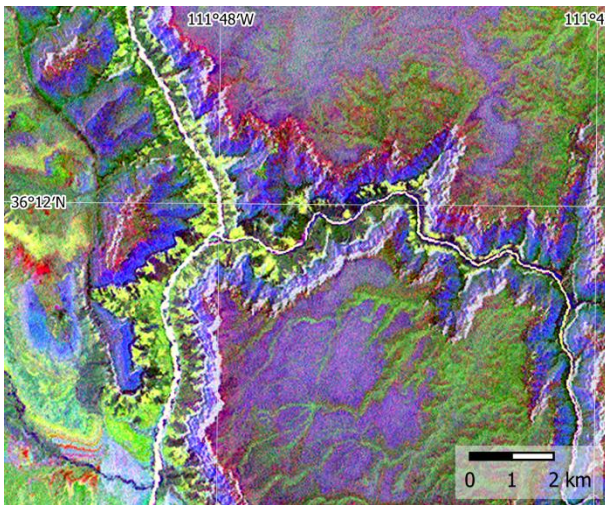
### **Carved into Sediment Layers**

The overview satellite image map shows a part of the Colorado Plateau in the south-west of the United States, which is intersected by the Colorado River. The Kaibab Plateau west of the Colorado River appears in a green colour as it is vegetated with aspens, spruce-firs and juniper woodlands. The Painted Desert in the east consists of coloured bands of petrified sand dunes parallel to the surface.

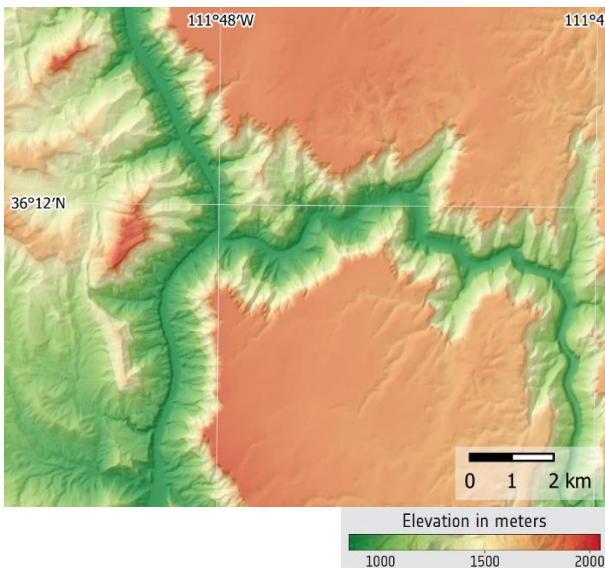
The Colorado flows from its headwaters in the Rocky Mountain National Park to the south-west. At the southern end of the canyon, the river is joined by the Little Colorado River. Together they flow through the Grand Canyon, which is a steep-sided gorge created by the Colorado River. Over millions of years the erosive force of the water has cut a channel through







PCA (Principal Components) map (Sentinel-2, 2023-09-24).



Elevation map. Data: Copernicus DEM.

the layers of sediments as the Colorado Plateau has been uplifted. The Grand Canyon is 446 km long and 0.5 to 29 km wide with a depth of up to 1,600 m. Landslides and mass wasting caused erosion and stream capture, which helped to increase the depth and width of the canyon.

The compilation of maps shows a detail of the Grand Canyon around the confluence of the Colorado River and the Little Colorado River. Together the maps highlight the specific geological and geomorphologic situation of the region, resulting from the fluvial erosion of the otherwise mostly undisturbed sediment layers.

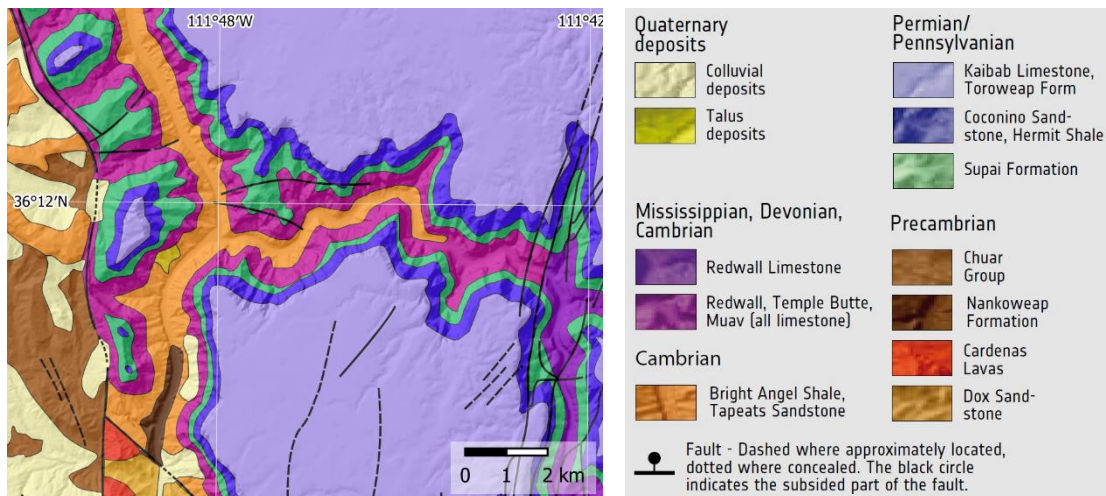
While it can be difficult to separate the geological zones in the near-natural-colour satellite image, they show up more clearly in the image processed using the so-called *Principal Component Analysis*. This technique is used to reduce redundancy of a dataset. This results in new and uncorrelated bands and hence in higher information content than the original bands. The new colours are random, but their interpretation allows separating geological issues in non-vegetated areas. The digital elevation map together with the profile illustrates the gorge character of the canyon, which is carved into the smooth, plain surface of the Colorado Plateau in the east.

## Exercises

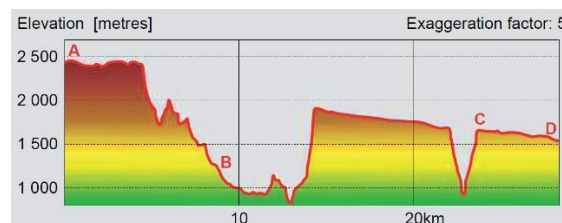
- Look at the overview satellite image and try to identify important land cover classes (e.g. bare land in the canyon, sparse vegetation in the east, tree cover in the northwest, and water).
- Looking at the satellite image maps, what can you say about the relief of the terrain? Where is it rugged, where flat? Which indicators support your findings? During which time of the year is the relief best visible in satellite images? Think about shadows and the sun position! Compare with the elevation profile shown below.
- Look at the false colour infrared map. Where can you find relatively intensive vegetation? Think about the role of water for vegetation especially in this semi-arid climate.
- Due to the different optical characteristics of different rock types a so-called principal components representation (PCA) as shown in the map is useful for geologists. Compare this map with the map showing the geological zones below. Find examples of geological formations that can be distinguished in the PCA map.



## Additional Material



*Geological map of the region around the junction of the Colorado River and the Little Colorado River. In this region, rock ages range from recent alluvial (river/rockslide) deposits via Permian (250-300 million years) and Cambrian (480-540 million years) to Precambrian (e.g. Dox formation, ~1140 million years).*



*West-East profile of the region south of the Little Colorado River  
(location: see overview satellite image map above).*

## Links and Sources

- [https://www.esa.int/ESA\\_Multimedia/Images/2009/07/Grand\\_Canyon](https://www.esa.int/ESA_Multimedia/Images/2009/07/Grand_Canyon) - ESA Envisat image of the larger region around the Grand Canyon.
- <https://landsat.visibleearth.nasa.gov/view.php?id=80948> - NASA Visible Earth presentation of the Grand Canyon.
- <https://rclark.github.io/grand-canyon-geology/#11/36.1859/-111.7493> - Interactive Geologic Map of Grand Canyon (Arizona Geological Survey).

