

How to use UltraFine+[®] Next Gen Analytics - Identify Proxy Regolith Types

What are proxy regolith landscape types and why are they important?

The UltraFine+[®] Next Gen Analytics workflow clusters publicly available spatial data to produce proxy regolith types. We call them *proxy* regolith types because they are derived via machine learning and not physically checked (ground-truth tested) for each site (although we have ongoing ground-truthing studies to provide further confidence that changes noted are observed in reality). Hence, the landscape clusters, or landscape types, are considered proxies for the physical regolith types in your project area.

Landscape types are essentially sub-populations within the sample set that can be assessed separately. The common “all soil samples” approach ignores the underlying processes that may affect metal dispersion. For example, high metal concentrations may be readily identifiable as outliers in a geochemical dataset where samples were collected over mineralisation beneath exposed outcrop or shallow residual materials. The same mineralisation would have a much weaker elemental signal in samples collected over moderately thick depositional landscape types such as a sand plain. It is therefore important to consider landscape context when evaluating soil geochemical results. By generating proxy regolith types, the UltraFine+[®] Next Gen workflow provides a basic, first-pass interpretation of regolith landscapes. This is used for the interpretation of anomalies in transported cover (see [How-to Outliers by Landscape Type](#)).

Where do I find the landscape models?

You will find your main files for landscape review in your *Data Package* under *2 Digital Sample Observer* (overview, kmeans4, agg8 or agg12). The *overview* is the best place to compare the three clustering algorithms before a more thorough assessment based on the preferred clustering output. Once you know which landscape model you prefer, you can find the outputs specific to each landscape model in your *Data Package* under *3 Landscape Models*. If you want to view your favourite landscape map as a TIFF file, go to *3 Landscape Models* → Choose your model → *1 Landscape Analysis* → *2 GIS*.

How do I determine what each landscape cluster represents?

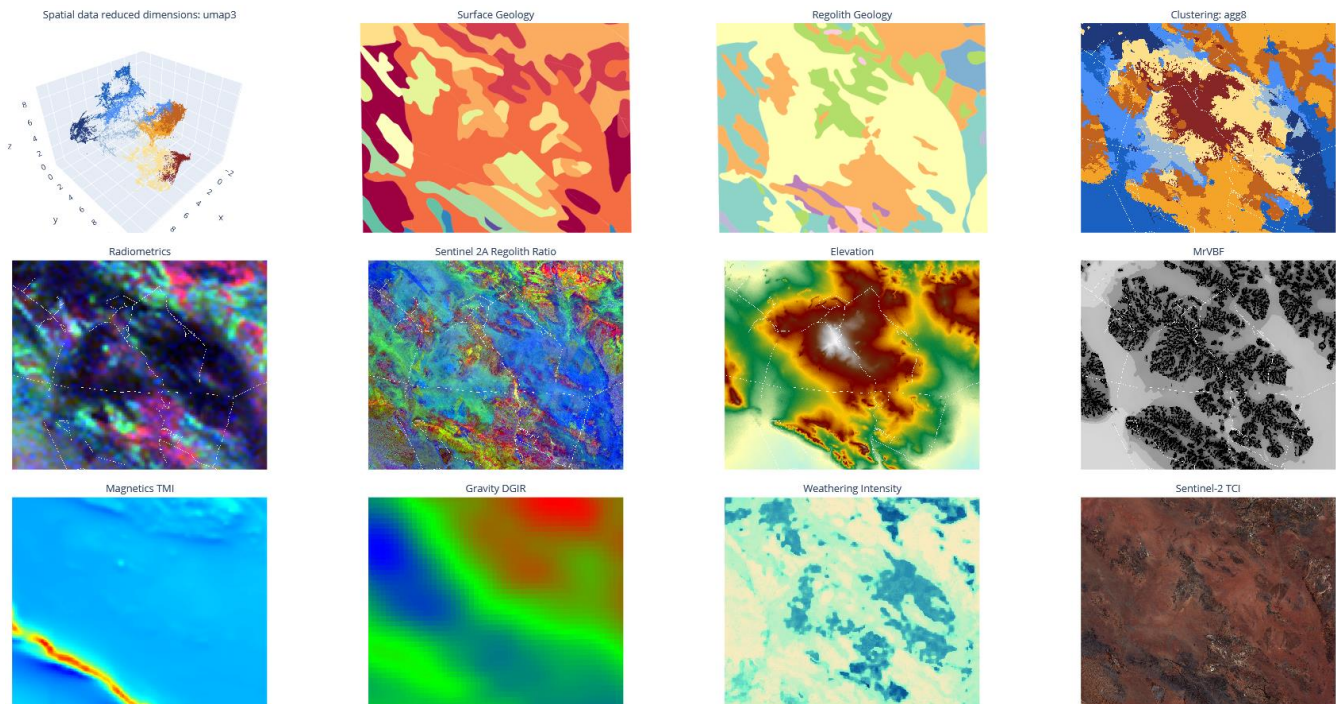
As a first pass, use your DSO.html tool to compare the landscape cluster map (of the model you have chosen or that we have recommended in the *readme.txt* file) with:

- Input layers (DEM, MrVBF, radiometrics and regolith ratios)
- Available surface and regolith maps
- Satellite imagery
- Weathering intensity
- Your knowledge/additional data. You know your project area best - utilise any other high-resolution data and your on-the-ground observations.

TIP: If you are unsure which landscape model to use (4, 8 or 12 clusters) read this [How-to guide](#) or head to your **readme.txt** file in your *Data Package* where you will find a recommendation for your site.

It is likely that most landscape clusters identify landforms/regolith materials that you are already familiar with, such as outcrops or drainage channels. However, there is a lot of value in dragging your landscape proxies TIFF file into GIS software so you can make comparisons to your field notes at specific points or with other map products.

The DSO allows you to zoom in on clearly identifiable features and look for similarities that will explain why these data are grouped. For example, zoom in on outcrops or residual hill areas (note the colour) and look for these features elsewhere. Is it the same colour? Commonly you will start to recognise the same colours corresponding to similar landform features. Other obvious landscape settings to observe are active fluvial channels, river terraces, deltas and large linear dune fields. Some features may be less clear – erosional mid slopes trending into foot slopes, toe slopes, and pediplains/sheetwash plains can overlap in the different landscape proxies.



Reviewing the clustering map with supplementary data provided in the DSO, such as surface and regolith geology, geophysics and more, can assist in understanding what the colour clusters (regolith proxies) are representative of.

Do I really need to name my landscape types?

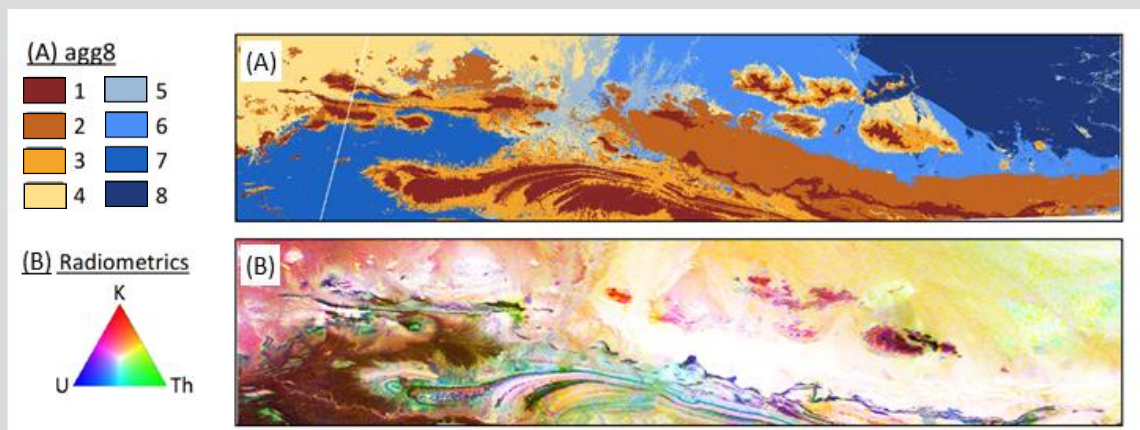
You don't have to give your landscape types a name, but you generally need to know whether you are looking at **depositional, residual or erosional landscapes** and if they represent **none, some, moderate or thick cover**. Some may be a mix such as residual soils trending into colluvial soils (erosional side slopes). Putting general notes or terms against the colours will help fine-tune your understanding of what the colours are commonly representing. You and your exploration team will know

your area well, and it is likely that you will easily associate certain landforms with a distinct colour of the machine learning derived proxy regolith types.

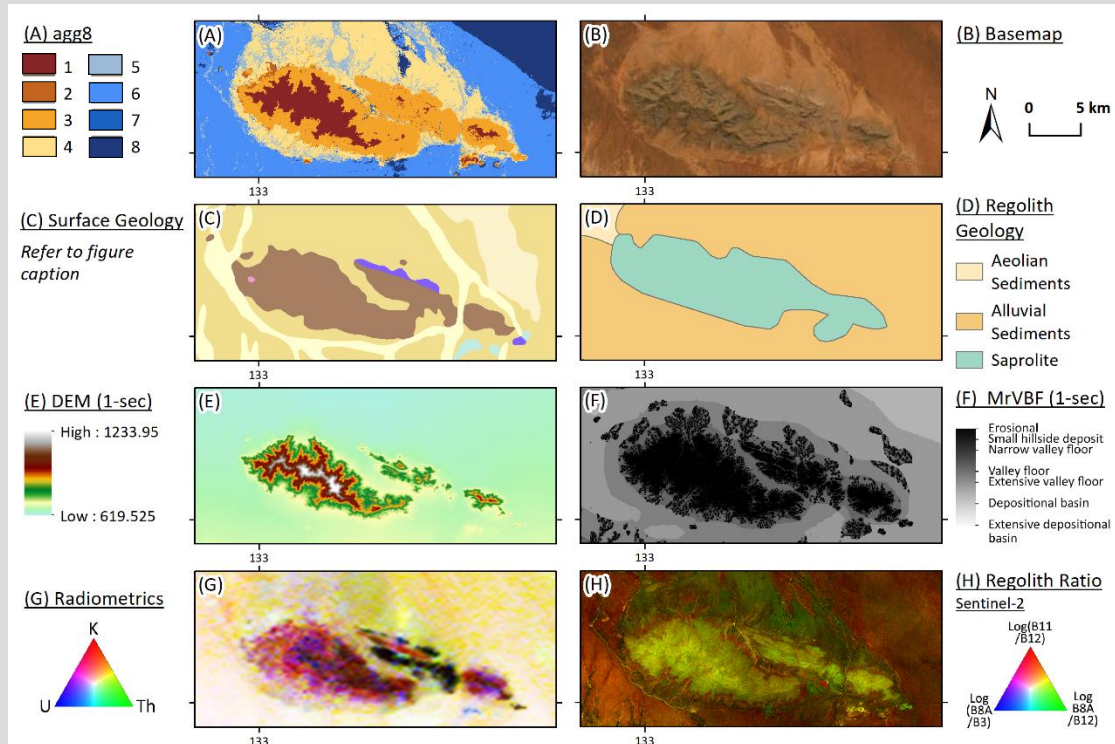
TIP: Hover your mouse over regolith and geology map units in the DSO to find out what they are and compare those to your landscape clusters to get a rough classification scheme.

NAMING LANDSCAPE CLUSTERS – AN EXAMPLE

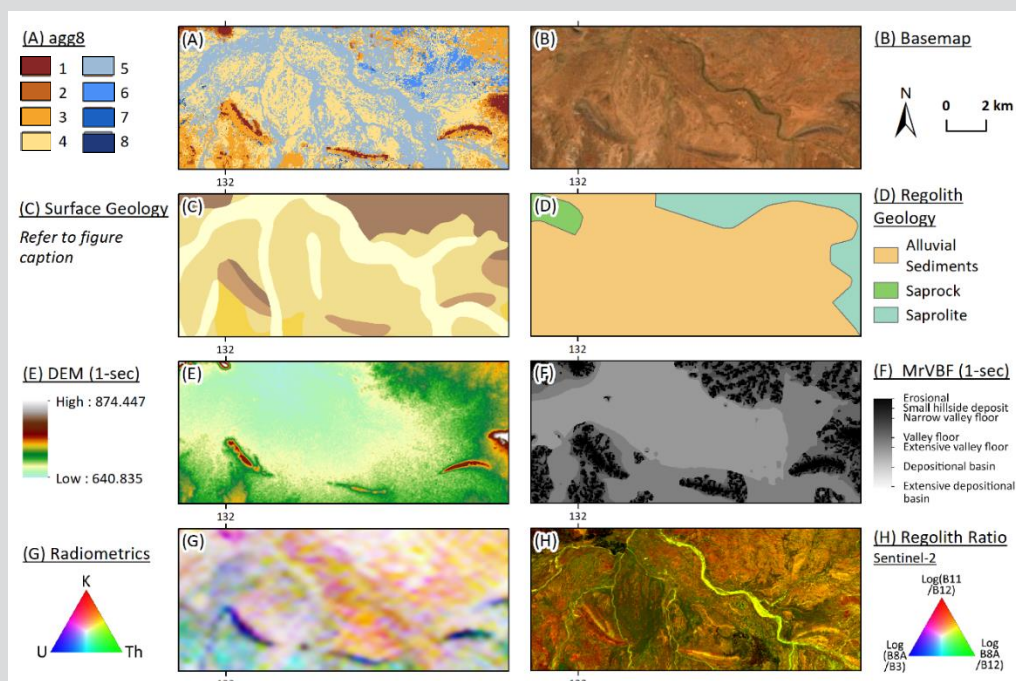
In the below example from the MacDonnell Ranges in the Northern Territory (read the full report [here](#)) anyone familiar with the general area will readily identify the dark red-brown and light brown clusters (A) as the elevated ranges, and a quick look at the radiometric data (B) will point out differences in parent material between the two. It is sufficient for our purposes (giving context to our geochemistry samples) to call these clusters outcrop/subcrop (dark-red brown) and residual (light brown) landscapes.



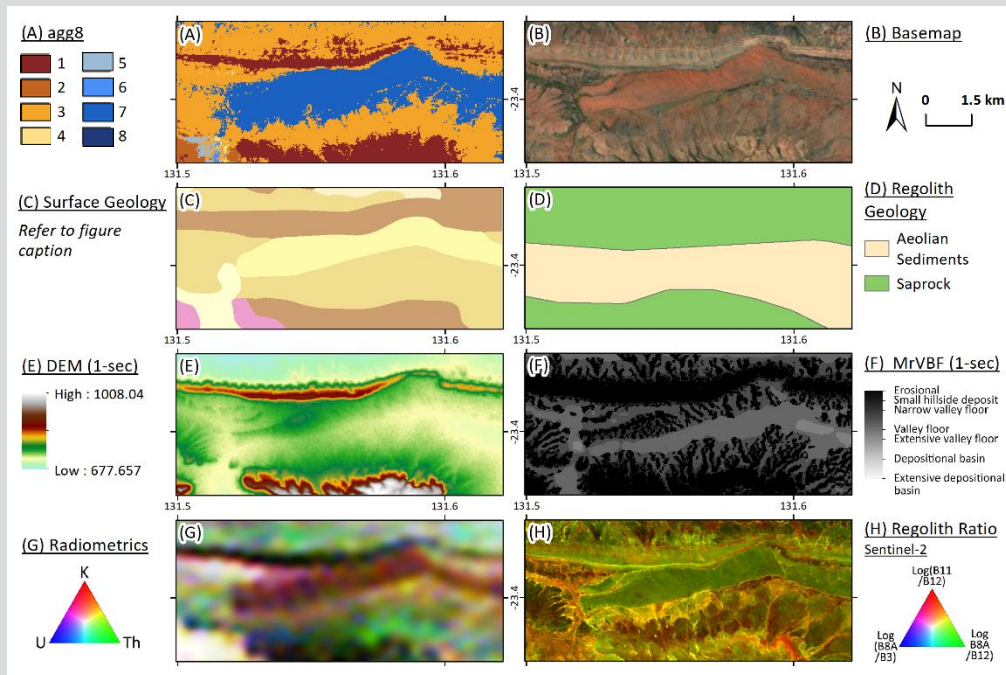
Now we would like to distinguish orange, light yellow and mid blue. While the satellite image below (B) shows a pronounced outcrop, the DEM (E) and MrVBF (F) indicate that there is a difference in landscape position and depth of cover between dark red-brown (outcrop) and orange, and we can call the orange cluster side slope. Further downslope, we head into light yellow and blue colours. The regolith ratio map (H) indicates a change in regolith materials, which is strengthened by a change in the radiometric signal (G) as well as the depth of cover (F). Both, light yellow and mid blue clusters, are mixed shallow cover, which we can term shallow cover 1 and shallow cover 2 for our purposes; the main distinction being the difference in depth of cover.



The light grey-blue colour in the above can already be identified as a landscape feature akin to fluvial channels. Zooming in on this cluster below, makes this clearer. We are in a generally low landscape position (E) with deeper cover (F) and the regolith ratio (H) very clearly picks out different regolith materials which match distinct river channels in the satellite image (B). We can comfortably call this light blue landscape cluster alluvial channels and/or floodplains, and the spatial association of this landscape cluster with surrounding colours gives us a little more information about the pale yellow cluster (mixed shallow cover 2) as well.



The blue clusters remaining are mainly distinguished by the depth of cover. An interesting example in the below image is the mid blue cluster wedged between side slope material (orange) shedding from outcrops/subcrops (dark red-brown) to the north and south. We are in a relatively lower landscape position (E) with deeper cover (F) and a distinct colour in the regolith ratio (H; indicating a change in regolith materials). The satellite imagery tells us we are looking at a sand dune. By confirming these same features in other parts of the area, we can comfortably identify the mid blue cluster with the broad term of aeolian cover.



Clustering the data into proxy landscape classes inherently puts a hard boundary on the data (the computer is forced to make a decision) even though, in many cases, there is a gradual change and the exact location of the boundaries is somewhat arbitrary. This is no different to other geological maps, although less biased than human interpretation, and samples near cluster boundaries should be considered when using the outputs. The below interpretation is sufficient to provide you with context for your geochemical outliers which have been calculated for each cluster.

Proxy regolith type by landscape cluster (agg8)

- | | |
|---|---|
| 1 Outcrop/subcrop (<i>residual</i>) | 5 Alluvial channels, floodplain (<i>depositional</i>) |
| 2 Residual (<i>residual</i>) | 6 Mixed shallow cover 1 (<i>depositional</i>) |
| 3 Side slope (<i>erosional</i>) | 7 Aeolian cover (<i>depositional</i>) |
| 4 Mixed shallow cover 2 (<i>depositional</i>) | 8 Mixed moderately deep cover (<i>depositional</i>) |

Do the colour tones indicate the regolith types and can I compare these to other surveys?

The colours in your outputs (for your 4, 8 or 12 landscape clusters) range from dark red-brown to dark blue and have been assigned based on the mean value of the MrVBF for each cluster. The lowest mean MrVBF values are assigned dark red-brown, and often indicate outcrop and subcrop. The highest mean MrVBF values are assigned dark blue, and often indicate areas of deep transported cover. However, the scale is relative (based on the lowest and highest mean MrVBF values in your area). For example, occasionally, the presence of elevated lowlands (e.g., depressions in higher elevation regions of your survey) or outcrops in otherwise deep cover (e.g., silcrete outcrops on salt lakes) can influence the order of landscape colours you might expect. Red tones are usually outcrop/sub-crop/residual cover grading into orange/yellows/light blues for side-slopes, channel deposits, shallow cover and the darker the blue the deeper the cover usually is on a relative scale within your project area. However, if for example, there is a “mountain” in your project area which will stick out as dark red-brown and the remainder of your area is low lying and covered in sand plain with a small hill with outcrop (low relative to your mountain but high relative to your sandplain) this small hill with outcrop will very likely not be coloured the same

residual dark red-brown, but instead may be a blue (or any other) tone. Hence the importance of reviewing these proxies before reviewing the outliers and results.

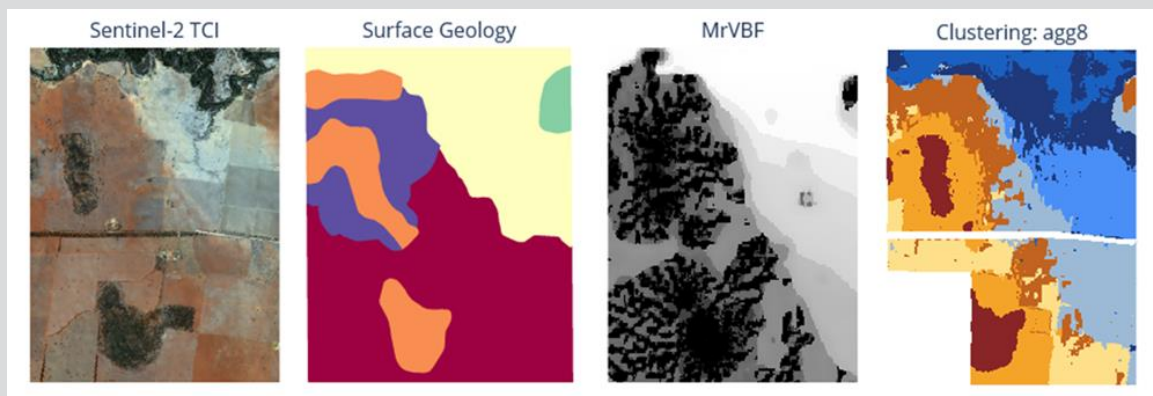
Each site is processed individually, and landscape clusters cannot be compared to other sites. What is yellow at a study site in the Pilbara is not at all comparable to what is yellow at a study site in the Yilgarn, or even on the adjacent tenement package if it was processed separately.

Why do some alluvial channels have different colours?

A key difference between our regolith proxies and a more typical regolith landform type surface map is that they are designed with surface geochemical exploration in mind. For surface exploration it is essential to evaluate anomalies distinctly based on the thickness of cover and the MrVBF provides this difference. However, this means that the machine learning derived maps for some areas might look a little different to what you are used to seeing from traditional landscape maps. This can be particularly pronounced for alluvial channels which might switch colours on the map. This is because the overall landscape cover thickness has changed with the MrVBF. Hence, although the samples may be in a similar geomorphological setting (fluvial channel) the depth of cover has changed. This is important information in the context of surface geochemistry, since the elemental signatures in deeper cover are likely to be weaker or perhaps unlikely to be detected with surface geochemical techniques. This enables better discrimination and consideration of the geochemical data. A similar observation occurs in sheetwash plains and sand plains as the landscape proxies extend across paleochannels. On the surface, they look similar, at depth there might be a lot of change with paleochannel features and this is ideally captured in the regolith proxy landforms (but won't be captured in a traditional regolith or surface geology map).

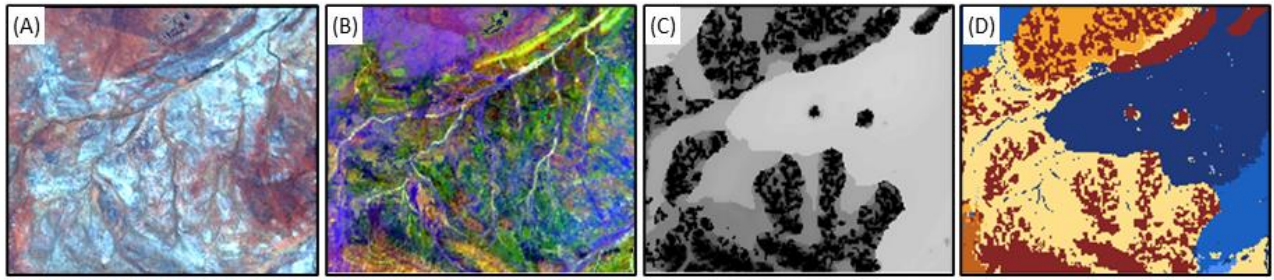
SIMILAR REGOLITH MATERIAL WITH CHANGING DEPTH OF COVER

In the below example, the Sentinel-2 true colour image shows a river on the northern (top) edge. The mapped surface geology notes the yellow unit as an alluvial plain and the dark red unit as a sand plain. The MrVBF shows changing depth of cover (from relatively shallow in the south to relatively deeper in the north) that are not reflected in the surface geology. However, in the landscape model the alluvial plain is broken into three shades of blue and the sandplain into three clusters of pale-yellow, mid-brown and grey-blue. These six landscape clusters show the gradual thickening of the cover as both the sandplain and the alluvial plain stretch away from the upland regions. From a geomorphological perspective, the surface geology is good, from a 3D exploration perspective it is overlooking key information that the clustering algorithm captures for the surface explorer.



“DISAPPEARING” ALLUVIAL CHANNELS

It is important to note that the maximum variability of input layers for each given data point will have the main “pull” on your landscape clusters. This means, a channel (A) might stand out in the regolith ratio (white in B). However, if there is a drastic change in depth of cover (C), the same channel could either be assigned a different landscape cluster or “disappear” as it does in the example below, when it enters from the light yellow into the dark blue landscape cluster (D). This usually happens in deeper cover and therefore samples in these areas will still be adequately considered in the context of landscape clusters where weaker geochemical signatures of interest are expected.



ALLUVIAL CHANNELS WITH DIFFERENT COLOURS

The example below shows drainage channels in an upland setting of $\sim 12\text{km}^2$. While the general drainage area is evident in the Sentinel-2 true colour image and in a more general but broader sense in the elevation and regolith geology maps, the clustering algorithm shows the drainage channel as mid-blue and dark blue. On the surface this region is similar, but the MrVBF shows the broader, flatter depositional nature in the channel, which affects the clustering model to separate the channel into two landscape proxies.

