

# QGIS in Mineral Exploration

Version: 1.1

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QGIS is an open-source GIS program for the display and analysis of GIS data. It has developed significantly in the past few years and is now a valuable tool for the mineral exploration industry, and a viable alternative to the commercially available GIS packages. Although not specifically written for geological applications, QGIS can do most of the required GIS tasks required by today's geoscientists. The terminology is different to the usual earth sciences programs, but many QGIS algorithms do the same thing but with a different name.

This manual examines QGIS and how QGIS can assist geoscientists in undertake mapping and geoscientific tasks in their day-to-day work. The manual has evolved during several years teaching QGIS to geoscientists in Australia and has been produced to offer a go-to document for earth science related GIS activities.

Accessing data from the internet via web map and web feature servers is illustrated to show how using this data can help with compiling available data for an area. Detailed aerial photography and Google Earth can be easily integrated with mapping data to allow the creation of accurate base maps for a variety of geological applications. A wide range of vector and raster (grid and image) data formats can be easily imported into QGIS, including GPS gpx files.

The presentation options for point, line and polygon data are extensive and easily customised. A variety of geological symbols and pattern fills can be applied to points, lines , and polygons. Geochemical and geophysical data can also be presented in a variety of display options. Basic 3D display of map data is also available via the QGIS2threejs plug-in and the QGIS 3D view. QGIS has many plug-ins for specialised tasks and the semi-automatic classification plug-in (SCP), is one example of where users can select, download, and process ASTER, Landsat, and Sentinel 2 satellite data. It is recommended that new users peruse the plugins list to see what plugins are available and for those that may be of use in their work.

Map production is easy in QGIS with the “Print Layout” allowing extensive options for the display and printing of maps.

This document is a working draft and in continuous development. There may be errors and omissions, and these will be rectified as time permits. This manual applies to QGIS 3.34.

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**Hint:** Looking for the PDF version? You can find it in the Read the Docs dropdown at the bottom of the left side panel.

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# CHAPTER 1

## ABOUT THIS MANUAL

This manual was originally written and freely distributed by Grant Boxer. To share it more widely, Grant and Mammoth Geospatial have collaborated to migrate it to a web-friendly format, following the lead of the [QGIS documentation](#).

We are offering this document as a donation to the QGIS geoscience community to assist new and existing users in developing their QGIS skills. QGIS is supported by a talented group of developers and we thank them for their efforts to continually improve the software. We consider QGIS to be of great benefit to students and those in the developing world where funding for proprietary software can be difficult.

We welcome community contributions! If you see errors or omissions, or have specific suggestions you think will make this more useful, please let us know by submitting an [issue via the GitHub repo](#). For more substantial contributions, we'd be happy to review pull requests.

### 1.1 Authors and maintainers

Grant Boxer has been using QGIS since 2015 after about 20 years using MapInfo Discover. He has been involved in exploration and mining geology for over 40 years, including almost 20 years with CRA Exploration Pty Limited, Argyle Diamonds and Rio Tinto Exploration from 1979 till 1997. Over the past 20 years (1998 - present) he has been consulting to the diamond exploration and mining industry with activities in Australia, Brazil, China, Greenland and India, and exploring for other commodities including base metals, iron ore, and manganese.

Mammoth Geospatial is an open source GIS consulting company based in Fremantle, Australia, with a focus on providing QGIS support and training to various sectors including mining and exploration.

### 1.2 Contributors

Thanks to these people who have contributed time to write, migrate, review, update, and maintain QGIS in Mineral Exploration.

Grant Boxer (original author)
John Bryant
Cholena Smart
Sam Hoppe

## 1.3 Licence

This manual is licenced under the Creative Commons [CC BY-NC-SA 4.0 licence](#).

## CHAPTER 2

### INTRODUCTION

This document is aimed at the exploration geologist, but the techniques outlined are easily transferrable to other areas. The author has been using QGIS since 2015 and the version used in this document is version 3.34.

The reader is encouraged to join the international online [QGIS user forum](#).

This document will not go into the detail that is covered by the official [QGIS User Guide and Training Manuals](#) and other reference books (e.g. Graser 2016) on QGIS on topics like editing etc., but will discuss those tools used particularly in geological mapping, mineral exploration and remote sensing. See [this video](#) for an explanation of some of the advanced editing functions.

## CHAPTER 3

### ABOUT QGIS

QGIS is a user-friendly open-source Geographic Information System (GIS) licensed under the GNU General Public License and is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats.

The Open Geospatial Consortium (OGC) is an international consortium of more than 530 businesses, government agencies, research organizations, and universities driven to make geospatial (location) information and services FAIR - Findable, Accessible, Interoperable, and Reusable. OGC's members create free geospatial standards. OGC also actively analyses emerging tech trends, and runs an agile, collaborative Research and Development (R&D) lab that builds and tests innovative solutions to members' use cases. For more information visit "ogc.org".

For those users requiring a “gentle” introduction to GIS, please see .

QGIS is a volunteer driven project. They welcome contributions in the form of code contributions, bug fixes, bug reports, contributed documentation, advocacy and supporting other users on their mailing lists and gis.stackexchange.com. If you are interested in actively supporting the project, you can find more information under the development menu and on the QGIS Wiki. If you find QGIS valuable in your workplace, please donate to the QGIS project - the details are on the website.

QGIS provides a continuously growing number of capabilities provided by core functions and plugins.

This document will mainly address workflows for geoscientists but there are many other tools available in QGIS and worthy of some exploration of their functions. Currently QGIS does not have a detailed downhole or cross section display option, but there are groups across the world that are crowd sourcing the development of the drill hole and cross section plug-in. The existing Geoscience plugin does display drill holes in plan and in cross section but is limited in its features. QGIS does not also handle all the various geophysical processing options, and again there is interest from various groups to develop plug-ins for geophysical processing.

A good explanation of QGIS and where it came from can be found [here](#). If you find QGIS makes a valuable contribution to your business, please consider [making a donation](#) to assist with continual code improvements.

Installation options are available on the [QGIS download page](#) with options to download either the development version (via OSGeo4W) or the standalone installers (recommended).

The original default file format for QGIS was the ESRI shape file (\*.shp) and this format has been around for many years and can be read by many software products. It is an old format and has limitations, e.g. field names are limited to 10 characters. QGIS has adopted the new “GeoPackage” file format as its default spatial file format. GeoPackage files can contain different types of vector geometry - points, lines and polygons - and can also include raster images. GeoPackage files can be up to 140 TB in size! Layers can be imported into an existing GeoPackage by dragging from the Layer panel onto the GeoPackage name in the Browser panel. Styling information can also be saved into the GeoPackage file. When digitising into a GeoPackage file, each new feature is auto numbered. Raster images imported into a GeoPackage appear to be significantly compressed

when compared with a GeoTIFF without any major loss of quality. ESRI and recent MapInfo products can read GeoPackage files.

Shapefiles have a number of limitations such as field/attribute column names are limited to 10 characters, it lacks a time data type, only supports text fields to 255 characters in length and is limited to 2 GB in size.

GeoPackage files on the other hand allows point, line vector and raster files to be stored in the one file. Formats/styles can be saved into the GeoPackage file and it can be up to 140 TB in size. When adding features during digitising, for example, a GeoPackage file will automatically populate the id field with sequential numbers. See [this web link](#) for further information. Note that GeoPackage files are single user only and if you need multiple user access at the same time then PostgreSQL and PostGIS may be required.

# CHAPTER 4

## INSTALLING QGIS

### 4.1 PC Installation

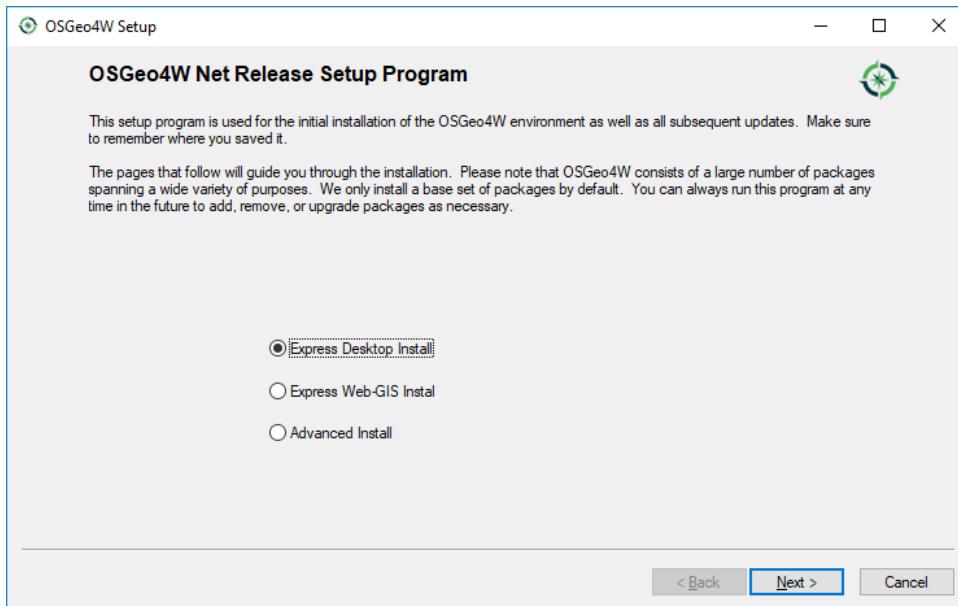
The QGIS program can be downloaded from the [QGIS Project website](#) and a choice can be made between various 64 bit versions of the recent release and long term release versions. The Standalone Installers will install the program into the Program Files directory.

The OSGeo4W (Open Source Geospatial for Windows) option can be also be used and this option places a small executable file on your PC which can be run when desired to update to the latest versions of the LTR and development versions. This version installs the software into the root directory of your PC (e.g. C:\OSGeo4W64). For first-time Windows users, it is recommended to install the “Download for Windows” option.

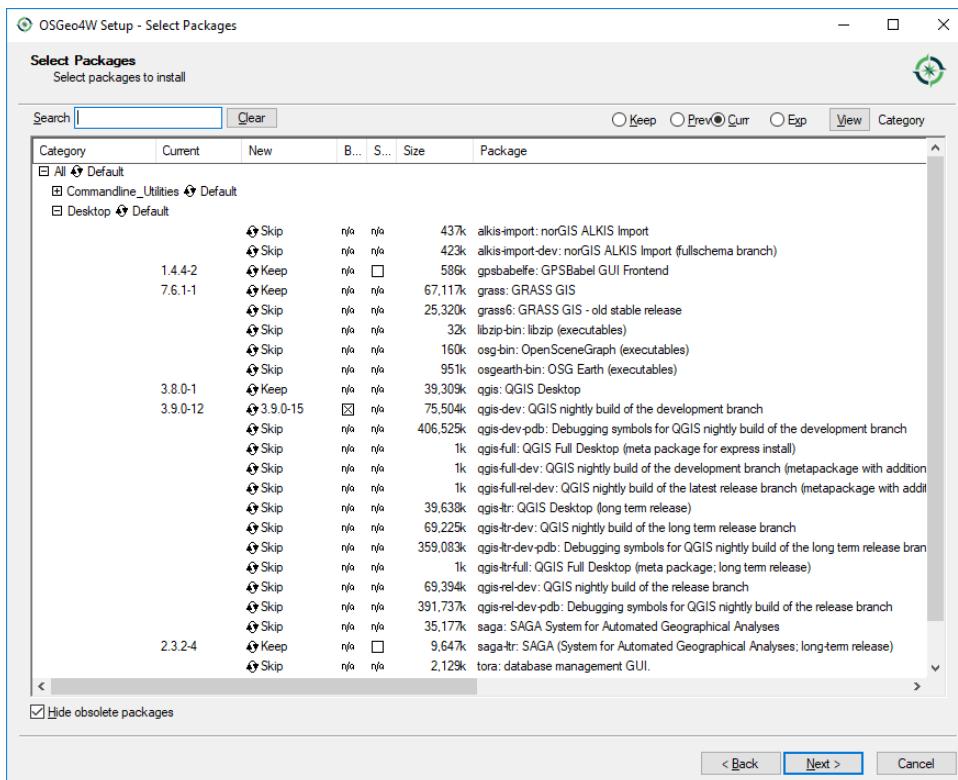
The screenshot shows the 'Download for Windows' section of the QGIS Project website. It features a large green button with the text 'Download QGIS 3.34' and a QGIS logo. Below the button, a link says 'Looking for the most stable version? Get QGIS 3.28 LTR'. A section titled 'OSGeo4W Network Installer' includes a description: 'The OSGeo4W installer is recommended for regular users or organization deployments. It allows to have several QGIS versions in one place, and to keep each component up-to-date individually without having to download the whole package.' A note at the bottom states: 'Since QGIS 3.20 we only ship 64-bit Windows executables.' Below this main section, there are four smaller sections: 'Download for macOS', 'Download for Linux', 'Download for BSD', and 'Apps for mobile and tablet'.

The installer (“Download QGIS 3.34”) will install the program into the program files folder and create a folder

on your desktop with shortcuts to the run the program. It is recommended to run the “QGIS Desktop 3.x with GRASS 7.x.x” version which runs the GIS program and associated GRASS GIS functions. When you run the OSGeo4W Network Installer option you will see the following screen shot. For a first-time installation, choose the “Express Desktop Install” which will install the basic programs and required utility files.

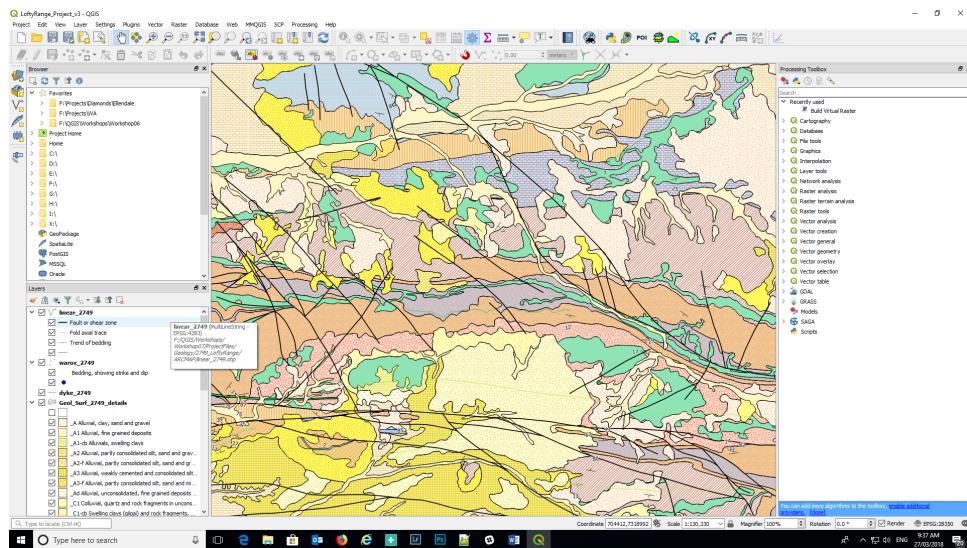


After the initial “Express Desktop Install”, this window will be different and you can then check for updates by running the “osgeo4w-setup.exe” file again (usually located in the Downloads folder) where you can then select “Advanced Install” and select which products you wish to update. The OSGeo4W option can be used instead of the Standalone Installer option.



The select packages window (above) indicates there is an update for v 3.9.0-12 to v 3.9.0-15 in the QGIS development version (old versions by way of illustration only!).

User manual and training documents can be viewed, or pdf versions downloaded from the [QGIS web site](#).



The QGIS desktop is similar to other GIS applications with menu items along the top and numerous buttons/icons to make it easier to select various options without having to navigate menus. All the menu items and panels are customisable to user preferences. QGIS has operations to import vector and raster data from a variety of formats into QGIS, with excellent editing and analysis tools from the integration of other GIS systems such as GRASS and SAGA. Some of these tools are illustrated in the right-hand panel of the figure above.

If you need to reset the QGIS window and/or panel locations, go to Settings > Options > System tab, select the Reset button (right hand side of screen) and re-start QGIS.

The appearance of the desktop can also be changed by using the Settings > Options > General tab and in the Application section find the “UI Theme” where the appearance of the desktop can be modified. A recent addition here is the “Blend of Grey” option.

## 4.2 Mac Installation

Installation on a Mac is different than for a PC and it is recommended to download and install QGIS from the QGIS download window.

Install the LTR or the Latest Release version.

[Download for macOS](#)

After installing QGIS, the first launch attempt may fail due to security protections. To enable QGIS, control-click on its icon in your Applications folder and select Open in the context menu. A confirmation dialog will display where you need to click the Open button again. This only has to be done once.

[Download QGIS 3.34](#)

Looking for the most stable version? Get QGIS 3.28 LTR

Alternatively, for native support of both Intel x86 and Apple ARM architectures, together with the latest versions of key components (e.g. GDAL, PDAL, GRASS GIS) see:  
[MacPorts Installing Instructions](#)

To install the custom (geological) SVG files on a Mac, in QGIS, go to Settings > Options > System tab and look for the location of the svg files - something like /Applications/QGIS3.app/Contents/MacOS/../Resources/svg/. Use the Finder to navigate to the Applications folder, then right click on the QGIS program icon, select “Show Package Contents”, open the “Contents” folder and the “Resources” folder. Put the custom (geological) SVG folders into the SVG folder.

## CHAPTER 5

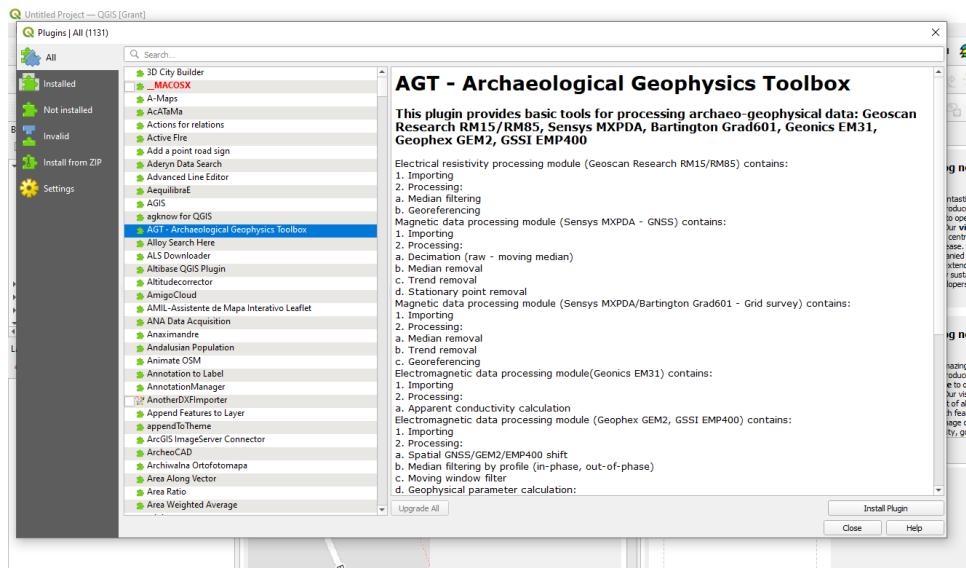
### PLUGINS

Plugins are small utility programs that greatly expand the capabilities of QGIS. There are currently over 1100 plugins available for download. These plugins are all free and have usually been written to solve a specific problem or task for users. It is recommended that users peruse the plugins list to see what plugins might be applicable to their workflow.

Ten “core” plugins are installed by default in version 3.34, listed below.

- DB Manager
- Geometry Checker
- GRASS8
- GRASS GIS provider
- MetaSearch Catalog Client
- Offline Editing
- OrfeoToolbox provider
- Processing
- Topology Checker

To use these pre-installed plugins, you may need to “enable” them in the Plugins > Manage and Install Plugins > Installed window. Enable the plugin by selecting the check box next to the plugin.

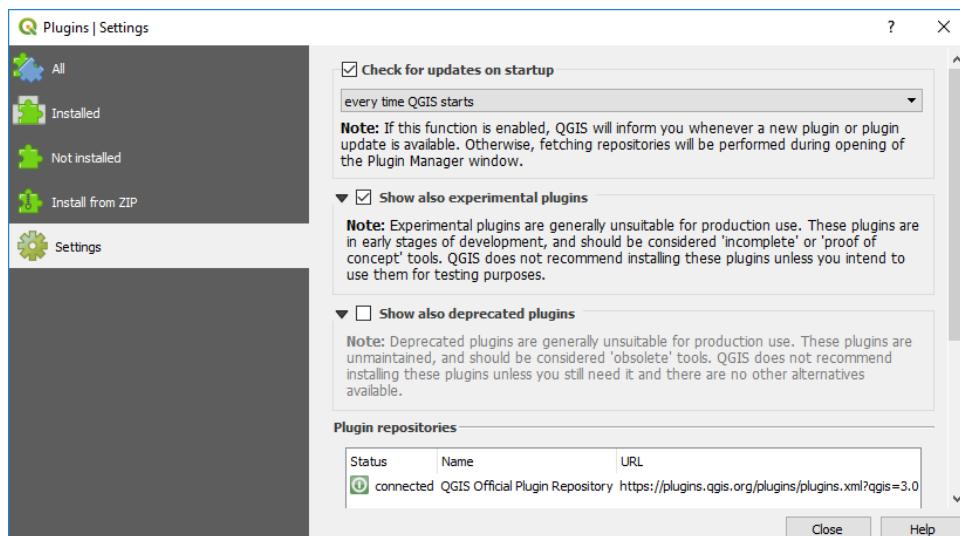


Additional plugins that are recommended are as follows;

- Data Plotly (graphing of data)
- Geoscience (for plotting drill holes on plans and sections)
- QuickMapServices (add additional services under the extra services option)
- QGIS2Threejs (3D viewer)
- Semi-Automatic Classification (satellite data selection and processing)
- Shape Tools (creation of numerous types of vector objects)
- Spreadsheet Layers (used to import Excel spreadsheets)
- SRTM Downloader (for accessing SRTM elevation data)

If the QGIS start-up is being significantly delayed during start-up (saying “Loading Plugins”) then they can be temporarily disabled by going to the Plugin Manager and un-tick those that are not needed or infrequently used. They can be turned on when needed.

In the Plugins > Settings page, check the “Check for updates on start-up” and “Show also experimental plugins”. This will then alert the user to updates of existing plugins and the release of new plugins whenever QGIS is started. Note that when you first open the Plugins manager, you may see a “New” tab to show you what new plugins have been released since you last opened the Plugin Manager. If you are working off-line with no internet, turn-off the “check for updates on start-up” to skip the web search and update function.



Some managed IT systems block the loading of the Plugin's repository data. If this happens, try selecting the Settings > Options > Network, and check the “use proxy server”. Try again to download the repository. If this loads the repositories, then uncheck this box and try again to install the plugins.

Network managers may also restrict the installation of plugins. If you have problems, contact your network manager.

# CHAPTER 6

## ACCESSING DATA OVER THE WEB

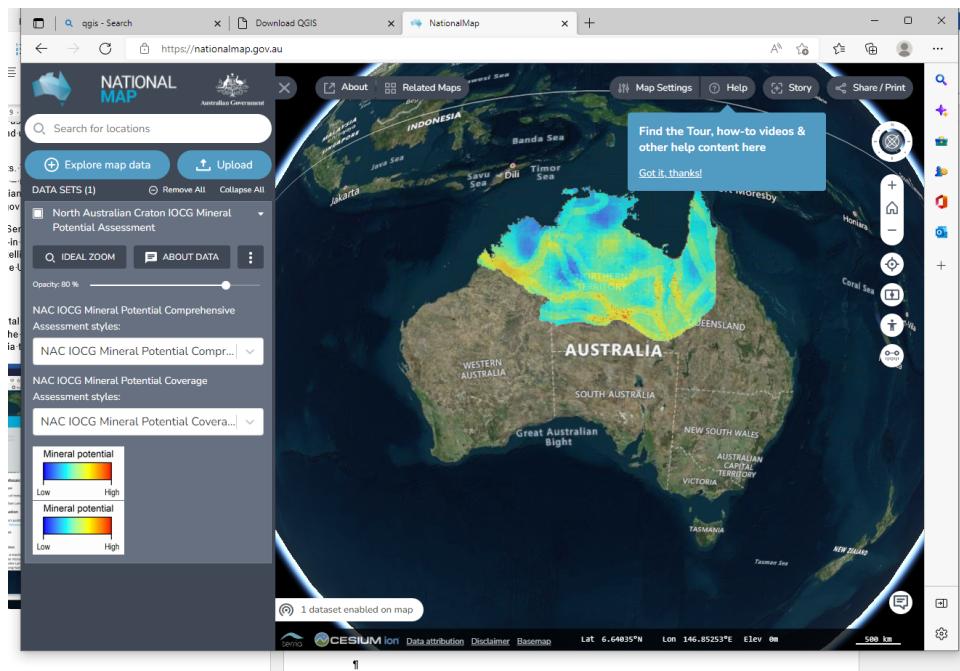
Many government and private corporations have made available datasets for use in GIS programs. There may be usage restrictions and the conditions of use should be checked at the data source. The amount of free data on the web is truly amazing and users are encouraged to explore the web for data.

QGIS has many options to access on-line web datasets. These can be in the form of a WFS (web feature service - vector data), WMS (web map service - raster data) or as a WMTS (web map tile server - tiled raster data, e.g. Google Earth). Australian data can be searched at “data.gov.au” and Western Australian data is available at “data.wa.gov.au”.

Satellite data for the ASTER, Landsat, MODIS and Sentinel missions can be downloaded and processed via the Semi-Automatic Classification plug-in in QGIS or via the USGS EarthExplorer portal and this is discussed below. Remote sensing satellite data (including Hyperion multispectral scanner and radar data) can also be downloaded via the USGS EarthExplorer and ESA (European Space Agency) websites.

### 6.1 Australian Data Sets

The Australian government has the [National Map portal](#) where data can be accessed for Australia-wide data sets or from the individual states and territories. The WA DEMIRS (Department of Energy, Mines, Industrial Regulation and Safety) data can also be accessed via this portal.



## 6.2 Geological Survey of Western Australia

The Department of Mines, Industry Regulation and Safety ([DEMIRS](#)) is home to the Geological Survey of Western Australia (GSWA). This site contains many data sets, most of which can be downloaded from the [Data and Software Centre](#).

Registered raster files of the 100k and 250k geological map sheets have been mosaiced into 1:1 million map sheet areas and are in jp2 (jpeg2000) format registered in GDA94 MGA grid coordinates. The “jp2” format contains the projection and registration data embedded in the file. Raster files of individual map sheets in either GDA94 lat/long or MGA can also be downloaded from the data centre.

Always check that QGIS is using the current coordinate reference system when it loads these files - GDA94 lat/log has EPSG 4283, GDA94 UTM zone xx is EPSG 283xx.

The digital vector files for the 250k and 100k geology sheets vary in their data content depending upon the age of the map sheet edition. The GSWA use ArcView for their GIS system and many of their datasets contain “lyr” style and GeoMap “gmp” files. It has been requested that the data supplied by the GSWA also contain the colour and pattern information to allow users of other GIS systems (like QGIS) to style their maps like the GSWA style. [North Road Consulting](#) have developed a plugin to convert “lyr” style files to QGIS style files and assists QGIS users to style their maps in a similar fashion to the Arc GSWA maps. Some of the recent regional geology releases by the GSWA do have .q1r files which are QGIS layer definition files.

## 6.3 Landgate and Open Data WA

The WA government has made available a large variety of GIS datasets through their Open Data portal ([data.wa.gov.au](#)). Data from other states can be accessed in a similar manner. Searches can be made on this site and both vector data and web service links are supplied. More detailed datasets are available for WA from Landgate, but they may require a subscription. Many datasets are however free, and registration is no longer required for the free datasets.

Links to some of the WA web services are as follows;

<https://catalogue.data.wa.gov.au/dataset/?organization=department-of-mines-industry-regulation-and-safety>

Use the search option to seek a particular data set, e.g. tenements.

The screenshot shows the dataWA website interface. At the top, there's a logo with a crest, followed by the text "dataWA". To the right are links for "Help Center" and "Contact Us", and a search bar with a magnifying glass icon. Below the header is a navigation menu with links for "Home", "Data", "Organisations", "Applications", "Groups", "SLIP", "Community", and "Public Sector". Under "Data", the "Datasets" link is selected, indicated by a blue underline.

In the main content area, there's a search bar with the placeholder "Filter by" and a dropdown menu set to "Location". A map of Australia is displayed with zoom controls (+, -, x). To the right of the map is a search input field with a magnifying glass icon and a "Clear all" button. Below the search bar, the text "547 datasets found" is displayed in bold. To the right, there's a "Order by" dropdown set to "Relevance".

Below the search area, there's a section titled "Organisations:" with a link to "Department of Mines, Industry Regulation and Safety". This section includes a green checkmark icon and the text "Mining Tenements (DMIRS-003)". A brief description follows: "Live and Pending Mining Tenement Data referencing both surveyed and unsurveyed mining tenements as they appear spatially within the Department of Mines, Industry Regulation and...". Below this are download links for various formats: SHP TAB GDB KML CSV XLS, FGDB, GeoJSON, SHP, GeoPackage, API ArcGIS Server Map Service, WMS, and WFS.

Further down, another section is shown with a green checkmark icon and the text "Abandoned Mines". A brief description follows: "The Abandoned Mine Sites database is an inventory of abandoned mine sites recommended by the Minerals Environment Liaison Committee in 1994. Following a fatal accident at an...". Below this are download links for GDB, SHP, and TAB.

Finally, there's a section titled "Operating Mines" with a green checkmark icon. A brief description follows: "MINEDEX provides a coordinated, project-based enquiry system for textual information on mine, deposits, prospects, etc., and related infrastructure. The Operating Mine Map...". Below this are download links for CSV, GDB, KMZ, and SHP.

Using Minedex as an example, this link allows you to connect to web services or download data (where available).

The screenshot shows the "Minedex (DMIRS-001)" dataset page. At the top, there's a breadcrumb navigation: Home / Organisations / Department of Mines, Industry Regulation and Safety / Minedex (DMIRS-001). To the right, there's a logo for the "GOVERNMENT OF WESTERN AUSTRALIA" and the "Department of Mines, Industry Regulation and Safety".

The main content area has a title "Minedex (DMIRS-001)". Below it, a description states: "Mines and mineral deposits of Western Australia: a spatial extract from MINEDEX database. MINEDEX provides a coordinated, project-based, inquiry system for textual information on mine and site locations (coordinates etc.), notice of intent to mine, mineral resources, mine production, mining inspection data, and environmental reports." It also notes that this dataset was formerly known as Minedex (DMP-001).

On the left, there's a "Access & Use Information" section with two icons: a green lock icon labeled "OPEN" and a Creative Commons license icon labeled "LICENSE". The "OPEN" section says "This dataset is available for use by everyone". The "LICENSE" section says "Creative Commons Attribution Non-Commercial 4.0". Below this is a "Preview in NationalMap" button with a globe icon.

On the right, there's a "Key Information" section with the following details:

- Published by:** Department of Mines, Industry Regulation and Safety
- Information classification:** OFFICIAL
- Data theme:** Natural Resources
- Data last updated:** 29-12-2023
- Update frequency:** daily
- Data custodian:** Manager Statutory and Resource Inf...

At the bottom of the page, there are sections for "Data and Resources" with expand/collapse buttons, and "Web Services & APIs", "Data Downloads", and "Resources" sections.

## Data and Resources

[Expand all](#) / [Collapse all](#)

### Web Services & APIs



#### ArcGIS Server Map Service

An ArcGIS Server Map Service offers access to a...

[Copy URL](#)



#### Web Feature Service

Web Feature Service (WFS) provides an interface...

[Copy URL](#)



#### Web Mapping Service

Web Map Service (WMS) is a standard protocol...

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### Data Downloads



#### Other spatial formats

Download in other data formats from the...

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#### Geopackage

This resource provides the latest snapshot of...

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#### File Geodatabase

This resource provides the latest snapshot of...

[Download](#)



#### Shapefile

This resource provides the latest snapshot of...

[Download](#)



#### GeoJSON

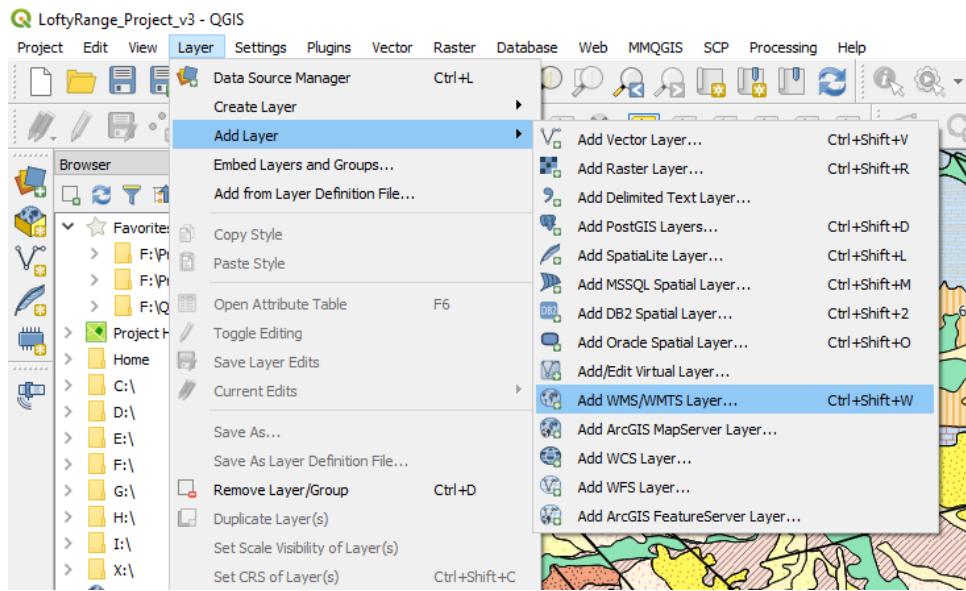
This resource provides the latest snapshot of...

[Download](#)

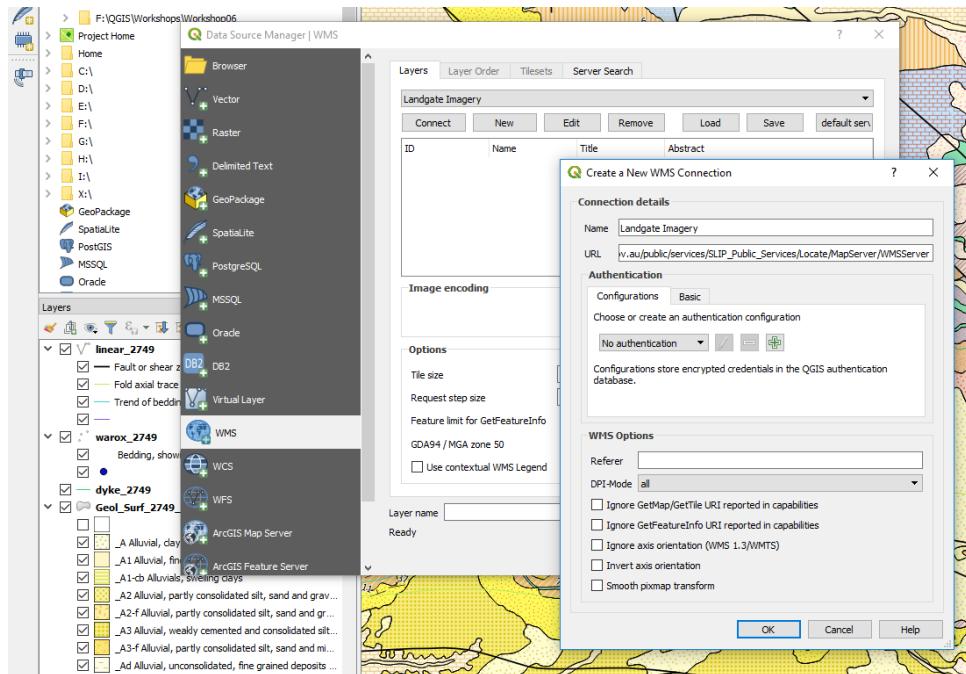
## Imagery

<https://catalogue.data.wa.gov.au/dataset/locate-wa-mosaic>

To add WFS and WMS layers to QGIS, use the Layer > Add Layer > Add WMS/WMTS Layer.

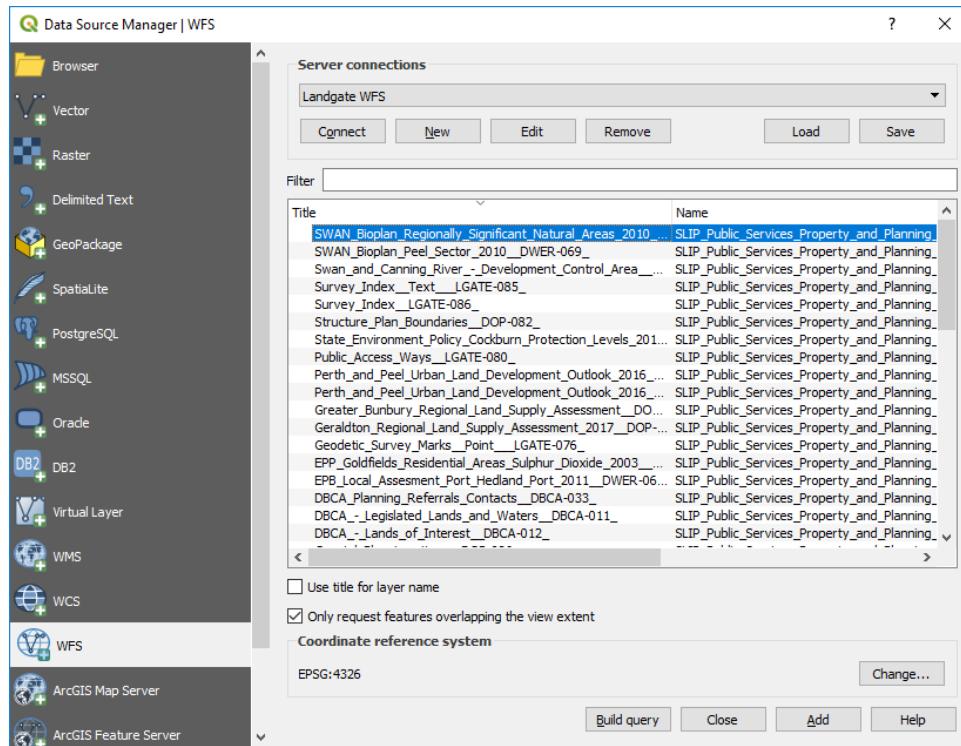


An example of linking to the Landgate imagery is shown below.



Some services may require you to register for a username and password.

Access to WFS vector data is via the add WFS (web feature server) option. See below for the list of publicly available data (no sign in required) from the Landgate server.



## 6.4 Geoscience Australia

Geoscience Australia (GA) provides an extensive array of national datasets via [data.gov.au](http://data.gov.au).

Digital elevation data is also available across Australia from [Geoscience Australia](#) at a resolution of 1 arc second (approximately 30 m) and is available as a hydrologically conditioned and drainage enforced version (DEM-H). This is a 26 Gb zip file and can be downloaded. The author has cut this into UTM zones which are approximately 7 - 8 Gb in size each zone to improve usability. Depending upon the speed of your PC/laptop, these may need to be further cut into 1:1 million map sheet areas. The 9 second DEM (approximately 250 m) is about 0.8 Gb in size, is also available.

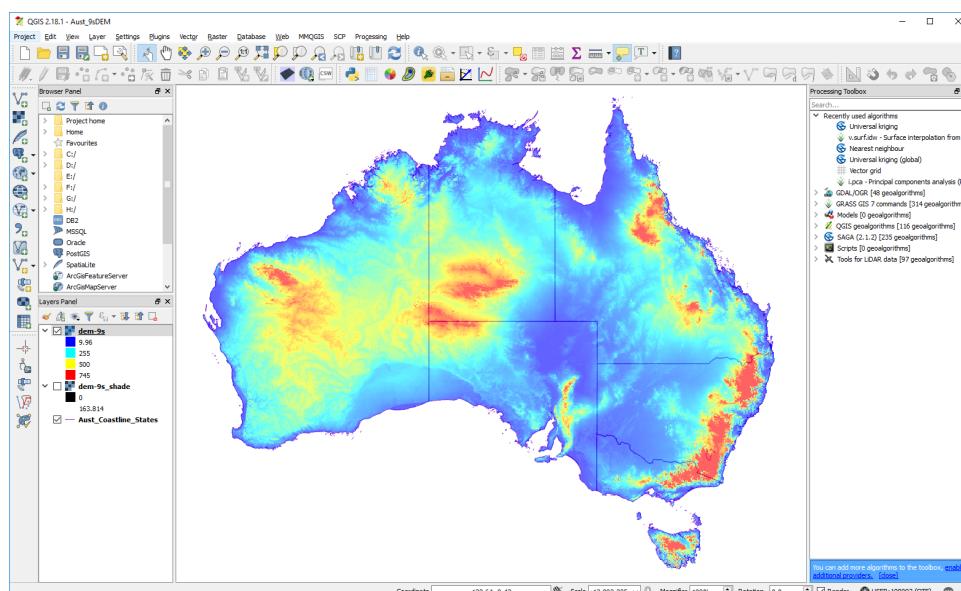


Fig. 1: Geoscience Australia, 9 second DEM

Many of these datasets are also available as web services.

Geophysical data incorporating magnetics, gravity, radiometrics and elevation data can be downloaded as vector (point data) or as grid files. Both national and individual survey data is available for data held by Geoscience Australia via the [Geophysical Archive Data Delivery System](#) - access via the “Tools” menu on the right hand top side of the window. DEMIRS will hold data for surveys flown for the GSWA. Data can be filtered by 1:250 000 map sheet area or by geographic coordinates. Check the projection of the dataset before you download, as it may default to geographic coordinates.

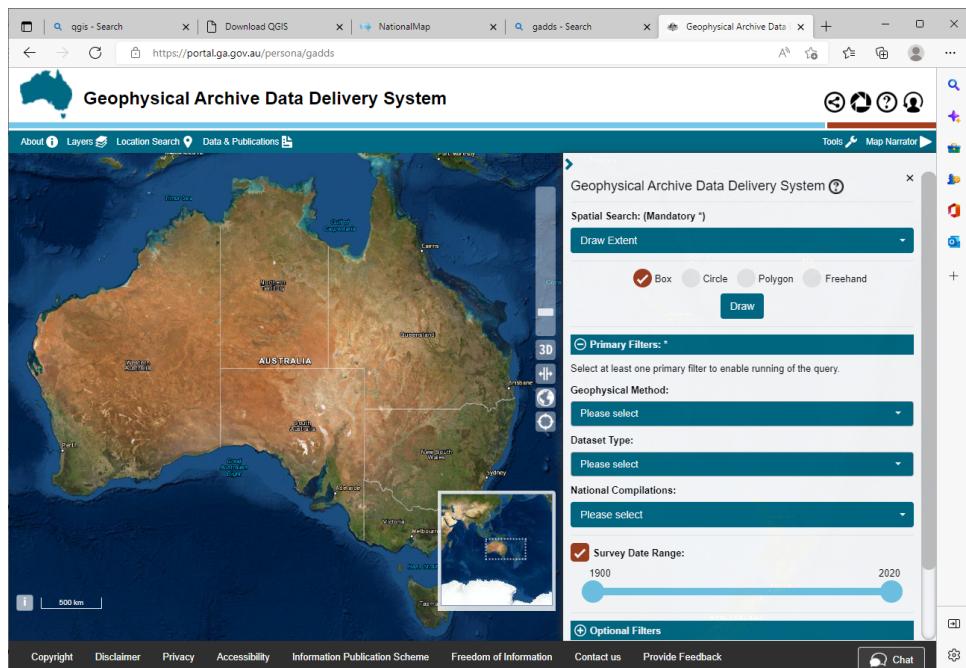
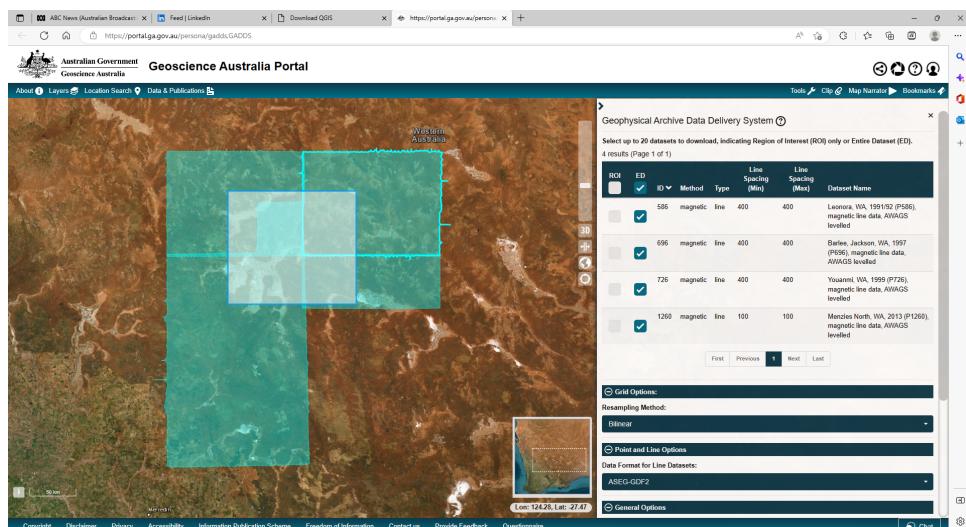


Fig. 2: Geoscience Australia geophysical data portal.



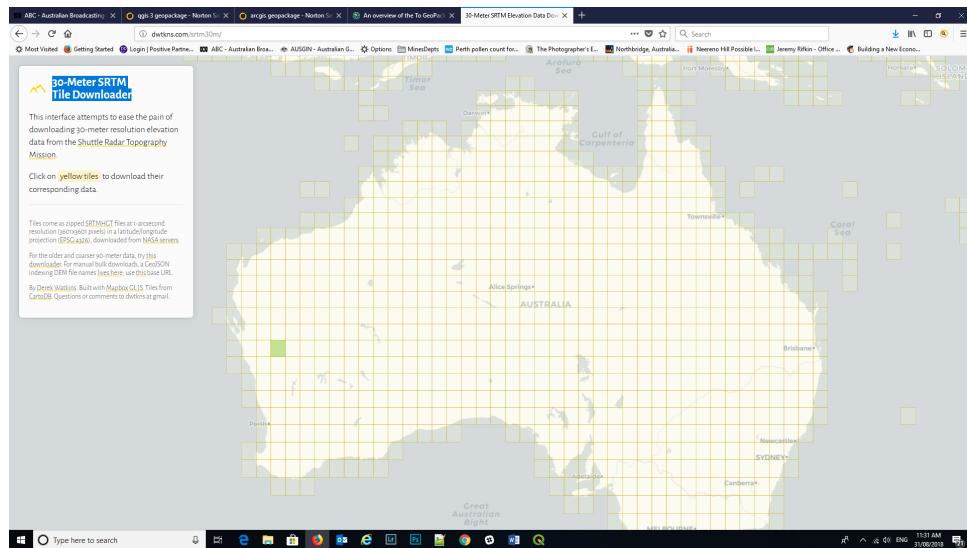
GA have also released a new Digital Earth Australia data portal.

## 6.5 Digital Elevation Data

World-wide digital elevation data is available from the USGS via their data portal, e.g., Earth Explorer, and Australian data can be downloaded from the Geoscience Australia ELVIS portal.

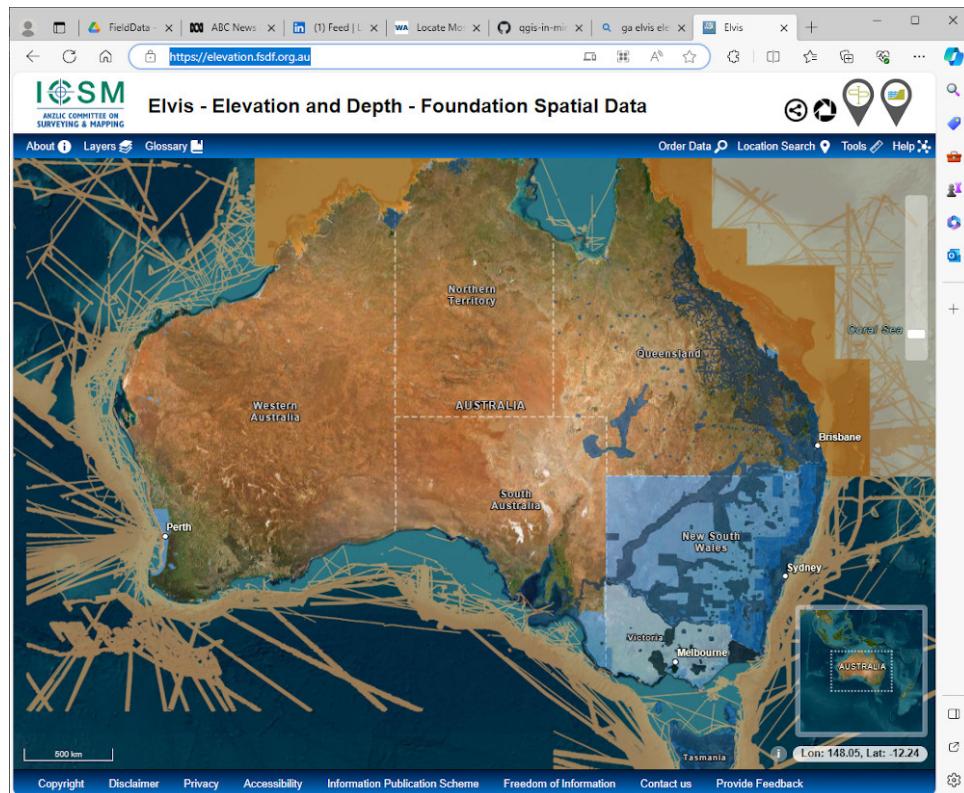
The SRTM-Downloader plugin allows the user to download tiles into their map window and these can be saved. Note that you will need a USGS EarthExplorer portal login (free). The dtm tiles are downloaded in one degree tiles in hgt grid format (which QGIS reads with no problem).

You can also use [this link](#) to access the 30m SRTM tile data. You will need to add your USGS EarthExplorer username and password.



These images are in jp2 (jpeg2000) format which have the image registration information incorporated in the file. QGIS reads and registers these images.

The ELVIS data portal can be accessed here "<https://elevation.fsdf.org.au/>".



## 6.6 Coordinate Reference Systems

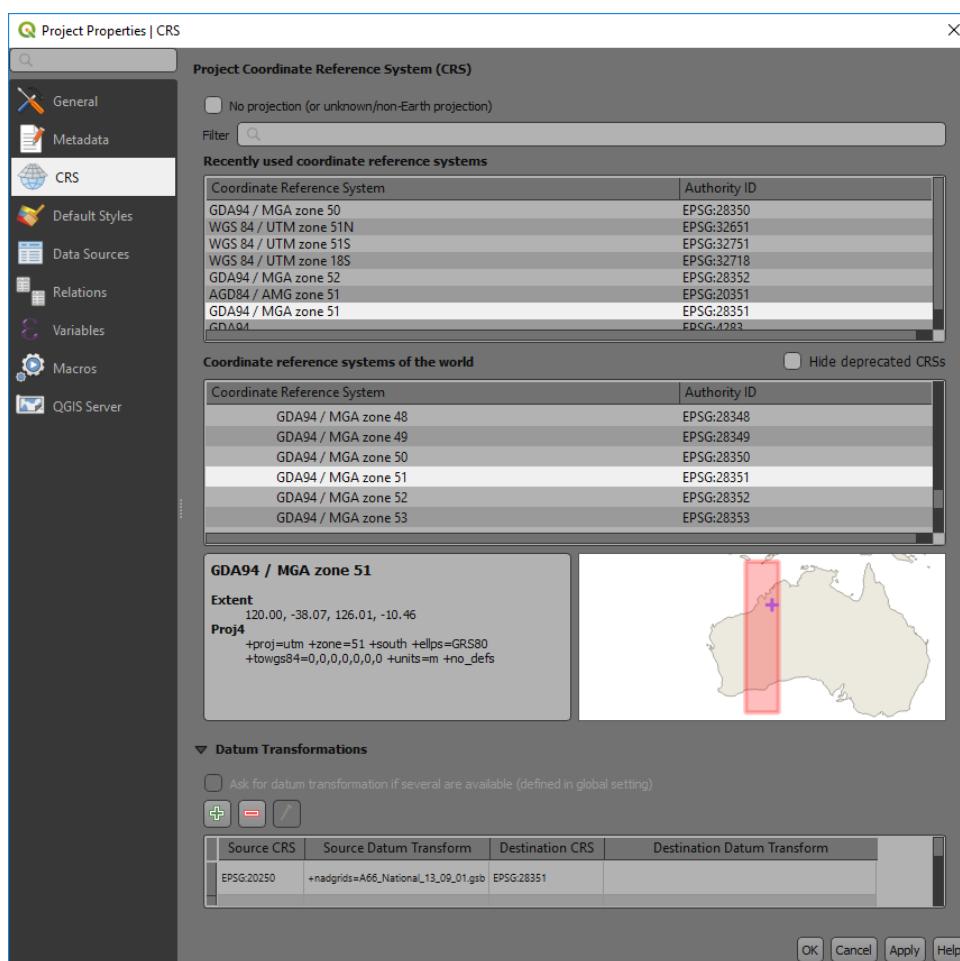
When using GIS data, it is very important to know the coordinate reference system (CRS) of the data. Choosing the wrong projection will misplace the data or prevent it from appearing on your map. QGIS can re-project data on-the-fly (OTF) when bringing data into a map window that has a different CRS to the file being imported. If QGIS cannot recognise the projection of the layer being imported, it will flash a yellow warning banner and usually defaults the layer projection to WGS 84. Open the layer properties for the layer and correct its projection.

Note that the CRS in the PROJECT PROPERTIES dialog box affects the way the data is displayed in the map window. The CRS dialog box in the LAYER properties box affects where the points are located on the planet. It is very important to know the CRS of the data being imported into the map window.

The CRS dialog box remembers your recent CRS used and these can be quickly selected from the “Recently Used...” information box. If you have not used a particular projection previously, you can type in the CRS name or EPSG number of the projection into the “Filter” box. For example, the Australian GDA94 geographic CRS has an EPSG of 4283. Note that if you type “GDA94” into the filter box it may give you an option of GDA94 as a Projected Coordinate System (EPSG 4938), this is incorrect and will cause problems when trying to display GDA94 lat/long data. Always check you have selected the correct CRS.

GDA94 UTM zones can be easily selected by entering the EPSG starting with “283”, then add the zone number, for example GDA94 zone 50 would be EPSG 28350. GDA2020 has a lat/long EPSG of 7844 and a UTM EPSG of 78xx where xx is the GDA zone number.

WGS84 UTM zones can be selected using “327” then the zone number for the southern hemisphere and “326” plus the UTM zone for the northern hemisphere.



The lower map window shows the area of the world where the projection is valid.

If you are using a local grid with no real world projection, you can select the “No Projection” tick box at the top of the window.

Note that in recent QGIS releases you get a coordinate transformation window open up when QGIS is reprojecting layers on the fly from WGS84 projections. QGIS is reminding you that the WGS84 projection transformations are only accurate to 2 to 3 metres.

# CHAPTER 7

## GEOLOGICAL DATA

Geological data is varied in nature but is usually either as points, lines, or polygons. Geological mapping comprises the collection of points using a GPS, with lines and polygons drawn as an overlay on aerial or satellite images. More commonly these days is that the data is collected in a portable field device and uploaded to the GIS database.

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**Hint:** When editing data, remember that in QGIS, it is a click to select and then click to the location to be moved - not a click and drag!

---

The following discussion covers a variety of tasks commonly associated with field data collection and interpretation. Detailed editing tasks will not be discussed as there are numerous resources available on the web, in the QGIS User Manual and various books. A variety of tips and tricks can be found in section 13.

The Android tablet application “QField” and MerginMaps are available for tablets and more details on this will be added in the near future. They can both be used in the field for data collection and mapping.

QGIS can sometimes have problems when digitising into layers with differing projections in the map window. It is recommended that digitising be done on layers in one projection at a time. The new file can be reprojected at subsequently into a different projection if required.

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**Note:** Turn off the *auto-save plugin* if you have this enabled, as it may cause problems during digitising.

---

Details on the digitising and editing functions can be found in the [QGIS User Guide](#). This guide gets regularly updated.

### 7.1 Point Data

Field mapping data is collected by various methods. The most basic version and that used by the “old school” is to collect data in a field book and then enter it into a spreadsheet for import into a GIS. Field data collectors vary in their formats and so the user will need to determine what is the best option for their data import. Always include the datum and projection zone (if applicable) when compiling vector data.

When importing data into QGIS, it must be decided whether the layers will created as shape files or created in a Geopackage. Shape files are in the original ESRI file format and has a number of limitations, such as field names limited to 10 characters. Geopackages do not have these restrictions but are typically single user files only, i.e., one user access at any one time.

GPS points collected in a GPS are easily brought in to QGIS by importing a GPS “gpx” file or in some cases direct download of the GPX file from the GPS. Tracks and waypoints downloaded from the GPS in gpx format

can be opened via the Data Source Manager and the GPS tab. GPX files from Garmin GPS units are usually in WGS84 geographic coordinates (Longitude and Latitude, decimal degree format) by default. GPS points can be uploaded to a GPS using the POI plugin.

Comma separated variable or “CSV” files are a good simple way to import point data and can be an alternative way to import spreadsheet data when there are problems importing Excel files. If you do have a problem with importing an excel file, save the file in CSV format and import into QGIS. Note there can be problems importing large Excel or csv files, e.g. with QGIS scrambling column data, if this is the case, then use the tab delimited text export option from Excel. Complex CSV files containing a variety of field types can be imported using CSV format files (\*.csvt). QGIS can read field data types from an OGR CSV driver compatible “csvt” file. This is a txt file alongside the data file, but with a “t” appended to the file name extension. The file should just contain one line which lists the type of each field. Valid types are “integer”, “real”, “string”, “date”, “time”, and “datetime”. The date, time, and datetime types are treated as strings in QGIS. Each type may be followed by a width and precision, for example “real(10,4)”. The list of types must be separated by commas, regardless of the delimiter used in the data file. An example of a valid format file would be: “integer”,“string”,“string(20)”,“real(20,4)”.

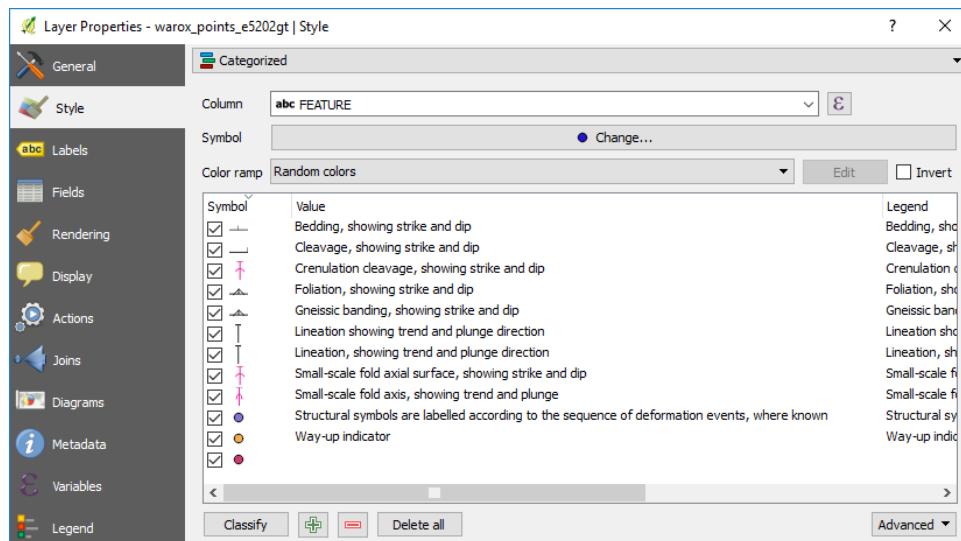
Another option for importing csv data is to load into Excel and check the field types for each field before importing. Excel files are imported using the “Spreadsheet Layers” plugin. This is found under the Layer > Add Layer > “Add spreadsheet layer” menu. It is especially important to check the data is being correctly imported.

Point geological mapping data such as bedding, joints and outcrop observations can be entered via a spreadsheet where columns can be created to cater for items such as coordinates, observations, and photo references.

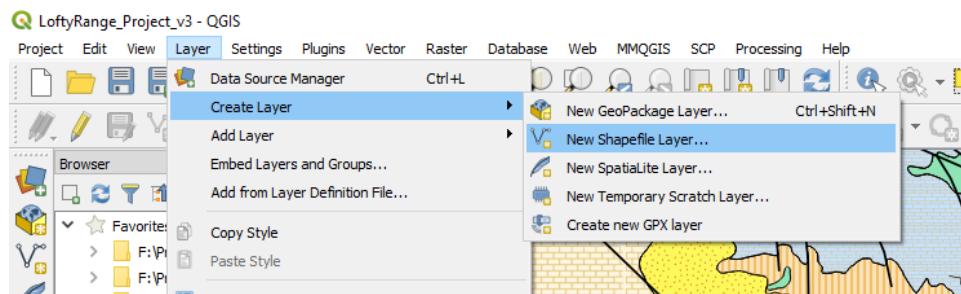
Remember to always include the datum and map projection data in the file. Symbol file names (full path required) can also be entered into the spreadsheet that will allow QGIS to select the correct symbol and then orientate it using a rotation angle for the correct strike or plunge. An example is shown below of the WAROX (GSWA mapping data, csv format) data from the GSWA Bow 1:100k geological map. Additional columns would be required with symbol file names to allow QGIS to select the appropriate symbol, or alternatively you can choose a “Categorise” symbol style option and edit the symbols for each category manually.

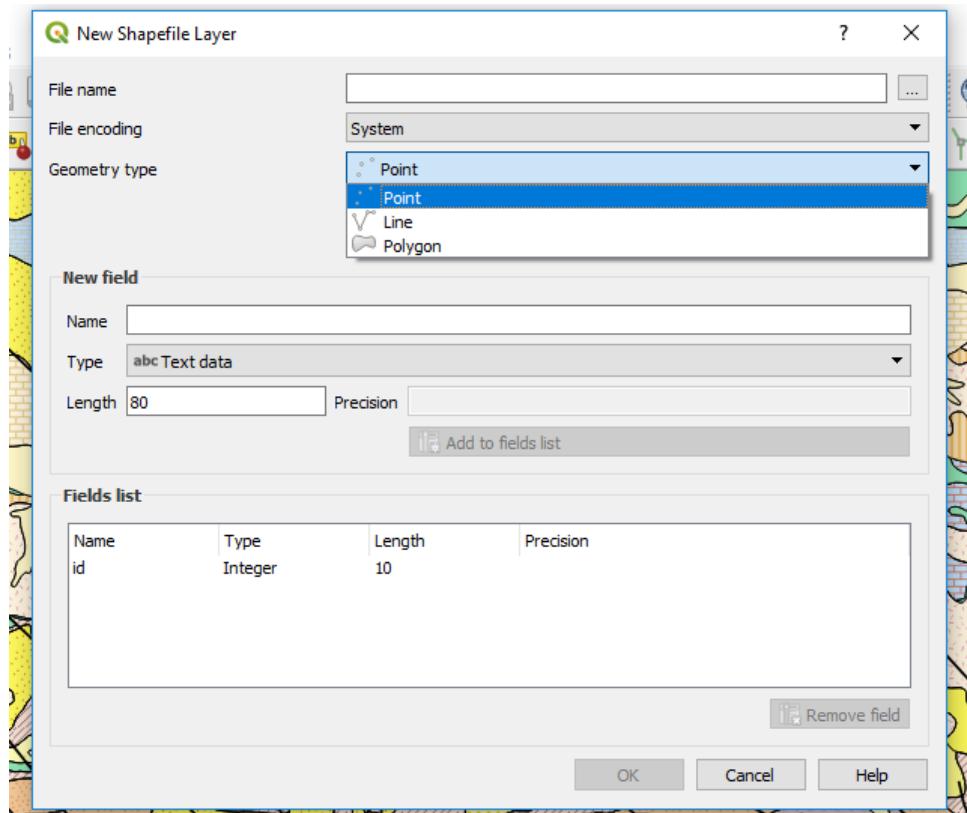
	X	Y	AREA	PERIMETER	GEOPNT	FEATURE	TYPE	STRIKE	DIP_DIR	DIP	PLUNGE	TREND	RANK	VERGENCE	SYMBOL	JNCODE
2	128.011	-16.509	0	0	1	1 Bedding, inclined	45	315	58	0	0	0	0	16	4564:Bedding, showing st	
3	128.026	-16.5084	0	0	2	2 Small-scal minor ant	0	0	0	0	38	0	0	455	4564:Small-scale fold axis	
4	128.3522	-16.5171	0	0	3	3 Bedding, inclined	351	81	11	0	0	0	0	16	4564:Bedding, showing st	
5	128.3728	-16.5147	0	0	4	4 Bedding, :strike and	42	312	0	0	0	0	0	28	4564:Bedding, showing st	
6	128.3945	-16.5245	0	0	5	5 Bedding, :strike and	357	87	0	0	0	0	0	30	4564:Bedding, showing st	
7	128.4046	-16.5122	0	0	6	6 Bedding, :strike and	65	155	0	0	0	0	0	28	4564:Bedding, showing st	
8	128.4195	-16.5082	0	0	7	7 Bedding, :strike and	331	241	0	0	0	0	0	28	4564:Bedding, showing st	
9	128.4368	-16.5518	0	0	8	8 Bedding, :strike and	287	197	0	0	0	0	0	28	4564:Bedding, showing st	
10	128.4072	-16.5458	0	0	9	9 Bedding, :strike and	87	177	0	0	0	0	0	28	4564:Bedding, showing st	
11	128.3951	-16.5365	0	0	10	10 Bedding, :strike and	22	112	0	0	0	0	0	30	4564:Bedding, showing st	
12	128.3831	-16.5393	0	0	11	11 Bedding, :strike and	4	274	0	0	0	0	0	30	4564:Bedding, showing st	
13	128.3791	-16.5306	0	0	12	12 Bedding, :strike and	28	118	0	0	0	0	0	28	4564:Bedding, showing st	
14	128.2913	-16.5468	0	0	13	13 Bedding, :strike and	8	98	0	0	0	0	0	28	4564:Bedding, showing st	
15	128.0352	-16.5543	0	0	14	14 Bedding, :strike and	55	325	0	0	0	0	0	28	4564:Bedding, showing st	

Below is an example of the “categorised” features of the WAROX data for the GSWA Lissadell 250k map sheet with features manually changed by clicking on each symbol. Once this has been done, remember to **save** the symbols by using the “Style” button and “Save style” to a QGIS .qml style file (e.g. GSWA\_WAROX.qml). This style file can then be used to recall these styles. You can choose the “save as default”, which creates a qml file with the same file name as the shape file and when you open the shape file, the qml file will be used to determine the way the features are displayed for this layer. Styles can also be saved to a GeoPackage file.



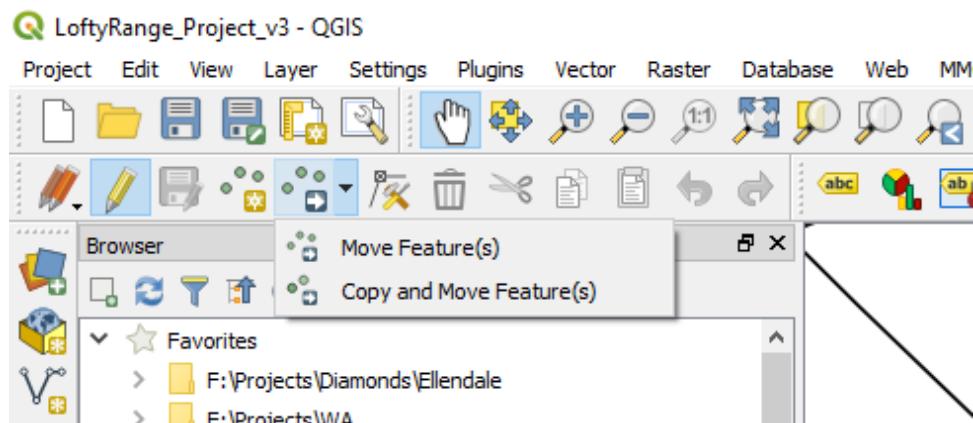
To create a new empty points layer, use the menu item **Layer > Create Layer > New Shapefile Layer** and select a point layer type (**especially important to check the geometry type! And CRS**). Add the required data columns and data types (text, integer, decimal number, date) to attach to each point. Remember shapefile column names are limited to 10 characters and any names longer than this will be truncated. When creating a new vector layer to digitise data, ensure the layer is the correct type, i.e. point, line or polygon, that it has the correct map projection and add the necessary columns to be able to enter the relevant field data for each feature. Save the file with an appropriate file name. Note that additional fields can be added later if needed. When digitising into a GeoPackage file the feature id will be automatically incremented.





**Note:** Note the Type “Real”, Length and Precision options where you can restrict the size of the data entered (e.g. UTM eastings length 9 - 6 figures, decimal point and two decimal places). A negative sign, as per the dip, does not use a length, so the dip field in this example could have a length of 5 (00.00 to -90.00).

Points can be moved in the map window by using the “Move Features” icon in the point edit menu. The layer requires to be set as editable. Note that the coordinates in the underlying table will not change and these coordinates need to be updated using the “\$x” and “\$y” geometry tools in the “Attribute Table”.

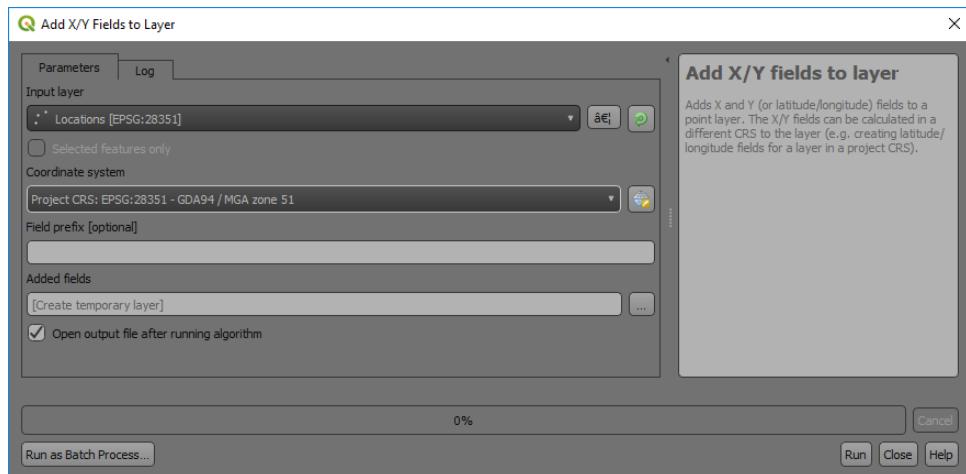


The move tool is highlighted in editing toolbar above.

If you do move points, remember to update the Easting and Northing values in the table using the geometry operator “\$x” for Easting and “\$y” for Northing. Remember to select the correct column to update! If you fail to do this the coordinates shown in the table will be incorrect. Remember also that the updated coordinates will be in the project projection coordinates. Also remember to save your edits.

	Datum	Zone	Easting	Northing	RL	ObsType	STRK_PLUNG	Dip	Comments
1.2 Easting	GDA94	50	397480.000000...	6741475.000000...	318.0000000000...				Pisolitic laterite o...
abc Point	GDA94	50	397560.000000...	6741440.000000...	313.0000000000...	Bedding	45.0000000000...	35.0000000000...	Outcrop of large ...
abc Datum	GDA94	50	397583.000000...	6741378.000000...	309.0000000000...	Joint	335.0000000000...	75.0000000000...	Breccia, vein qtz ...
abc Zone	GDA94	50	397583.000000...	6741378.000000...	309.0000000000...				Y
1.2 Easting	GDA94	50	397643.000000...	6741345.000000...	305.0000000000...	FoldAxis	25.0000000000...	45.0000000000...	Breccia, smaller c...
1.2 Northing	GDA94	50	397643.000000...	6741345.000000...	305.0000000000...				Y
1.2 RL	GDA94	50	397470.000000...	6741470.000000...	318.0000000000...	Bedding	50.0000000000...	35.0000000000...	Top of pisolite hill...
abc ObsType	GDA94	50							N
1.2 STRK_PLUNG									
1.2 Dip									
abc Comments									
6 GB05	GDA94	50	397643.000000...	6741345.000000...	305.0000000000...				Y
7 GB06	GDA94	50	397470.000000...	6741470.000000...	318.0000000000...	Bedding	50.0000000000...	35.0000000000...	Top of pisolite hill...

There is an algorithm in the Processing Toolbox that will create X-Y columns from point data and this is accessed via the Processing Toolbox > Vector Table > “Add X/Y Fields to Layer”.



## 7.2 Outcrop Photographs

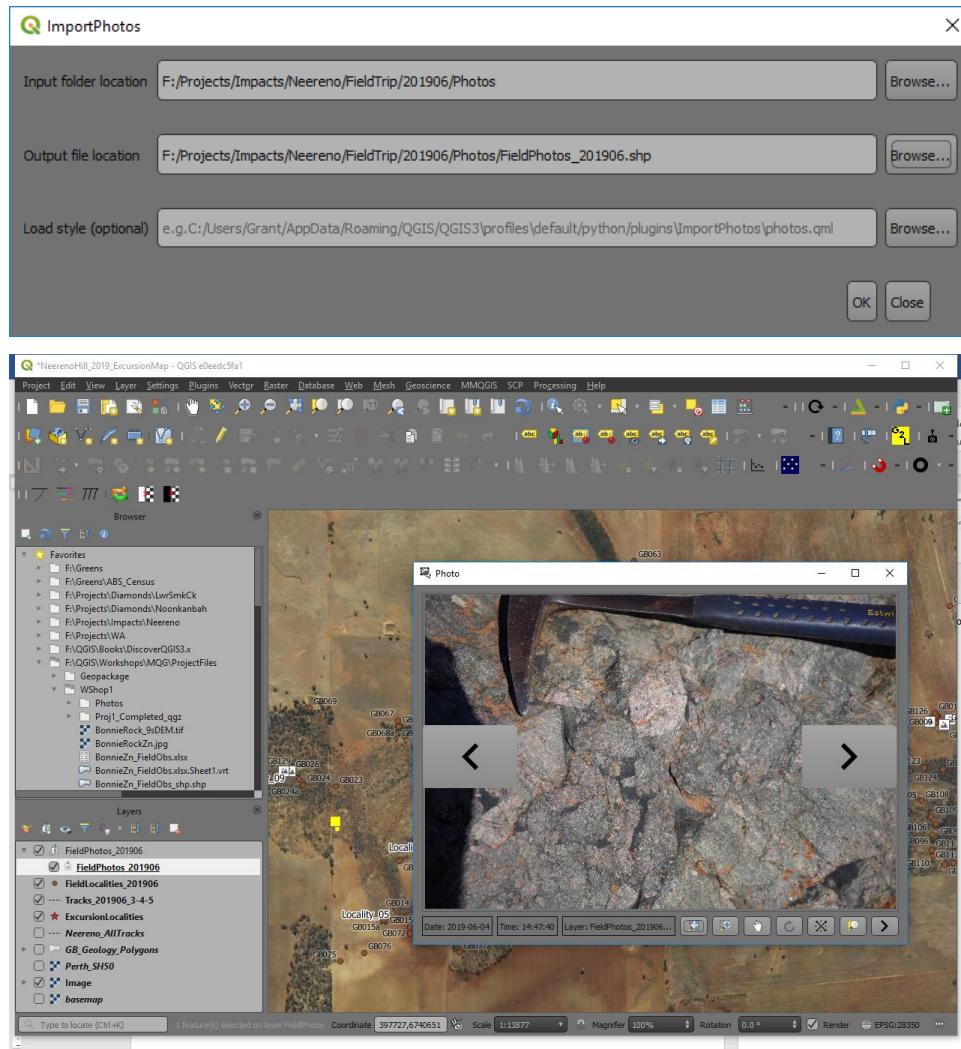
Photographs of outcrops and report pdf files can be attached to an observation point and allow a point and click to access the photo or report.

There are three ways to display photos at points. There are two options using the Import Photos plugin, and the third option is going via the Layer Properties > Actions (thanks to Mike Erceg for explaining this process) The last two options require the full path to the photo file to be identified.

### 7.2.1 Import Photos Plugin

If your photos are geo-tagged, i.e., they have their coordinate locations embedded in the file, then another alternative option is to use the “Import Photos” plugin. Most smartphones take geo-tagged photos unless the location data option has been turned off for photos. I use a Pentax K-1 DSLR and that camera has an in-built GPS, so all photos are automatically geo-tagged. Most smart phones will have embedded GPS coordinates in the photos unless this location feature has been turned off.

To use the Import Photos plug-in, run the “Import Photos” option and select the directory where the photos are located and where you want to store the resulting shape file (this will have all the photo information extracted from the photo file). Choose a suitable filename and press OK. The layer will then be created and using the Plug-Ins > Import Photos > Click on Photos (use a double click), the photos in those locations will be displayed



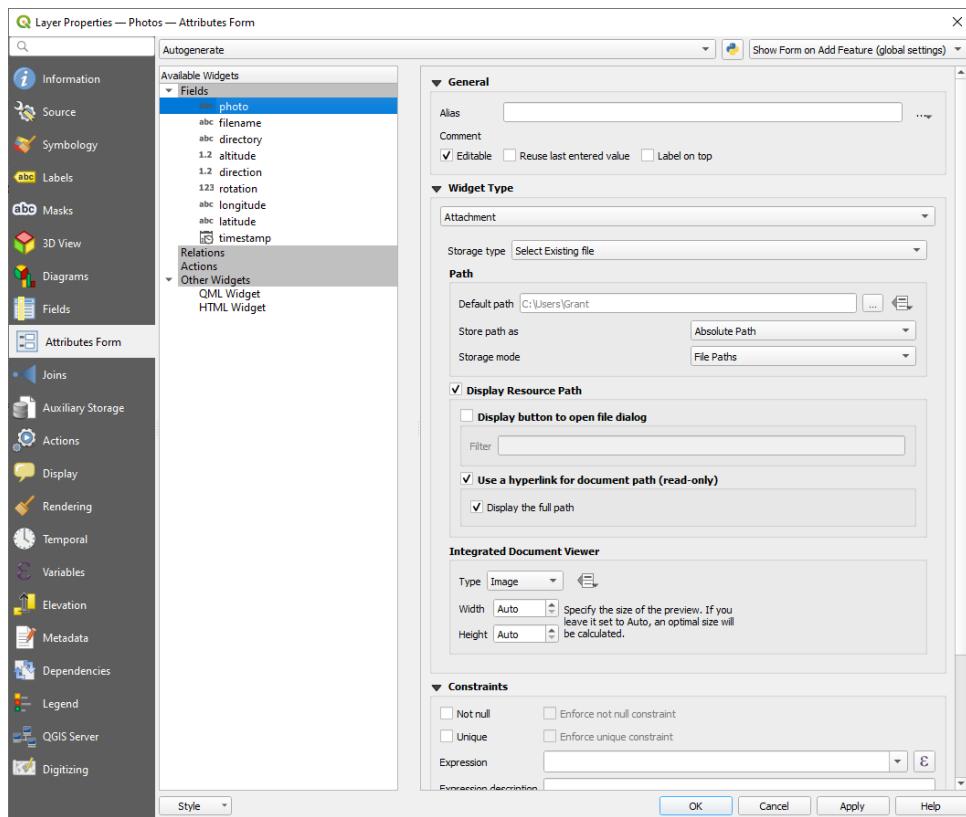
## 7.2.2 Import Geotagged Photos

This is the simplest option if your photos are geotagged. Most smartphones automatically geotag photos unless this “location” feature is disabled. Use the Processing Toolbox > Vector Creation > Import geotagged photos algorithm. The resulting table will be created as below.

photo	filename	directory	altitude	direction	rotation	longitude	latitude	timestamp
1 J:\Dropbox\Ne...	GLB_6068	J:\Dropbox\Ne...	300.6	283.06	0	115.9493316666...	-29.4488716666...	4/06/2019 12:02...
2 J:\Dropbox\Ne...	GLB_6069	J:\Dropbox\Ne...	295.2	165.04	0	115.9490116666...	-29.4491033333...	4/06/2019 12:05...
3 J:\Dropbox\Ne...	GLB_6070	J:\Dropbox\Ne...	297.2	154.85	0	115.9483066666...	-29.4489333333...	4/06/2019 12:07...
4 J:\Dropbox\Ne...	GLB_6071	J:\Dropbox\Ne...	297.2	150.42	0	115.9483016666...	-29.4489366666...	4/06/2019 12:07...
5 J:\Dropbox\Ne...	GLB_6072	J:\Dropbox\Ne...	290.5	184.54	0	115.9405233333...	-29.44945	4/06/2019 13:59...
6 J:\Dropbox\Ne...	GLB_6073	J:\Dropbox\Ne...	289.8	184.08	0	115.94053	-29.4494516666...	4/06/2019 13:59...
7 J:\Dropbox\Ne...	GLB_6074	J:\Dropbox\Ne...	290.3	184.7	0	115.9405316666...	-29.4494216666...	4/06/2019 14:00...
8 J:\Dropbox\Ne...	GLB_6075	J:\Dropbox\Ne...	291	227.93	0	115.9405716666...	-29.4494316666...	4/06/2019 14:00...

To display photos, you use a widget in Layer Properties > Attributes Form. In the above example, the “photo” contains the link to the photo and we can use this to tell QGIS where to find this photo. Open the Layer Properties of the file and select the “Attributes Form” tab. Select the field with the link to the photo (“photo”), then change the widget type to “Attachment”.

Leave everything else as default, see image below.

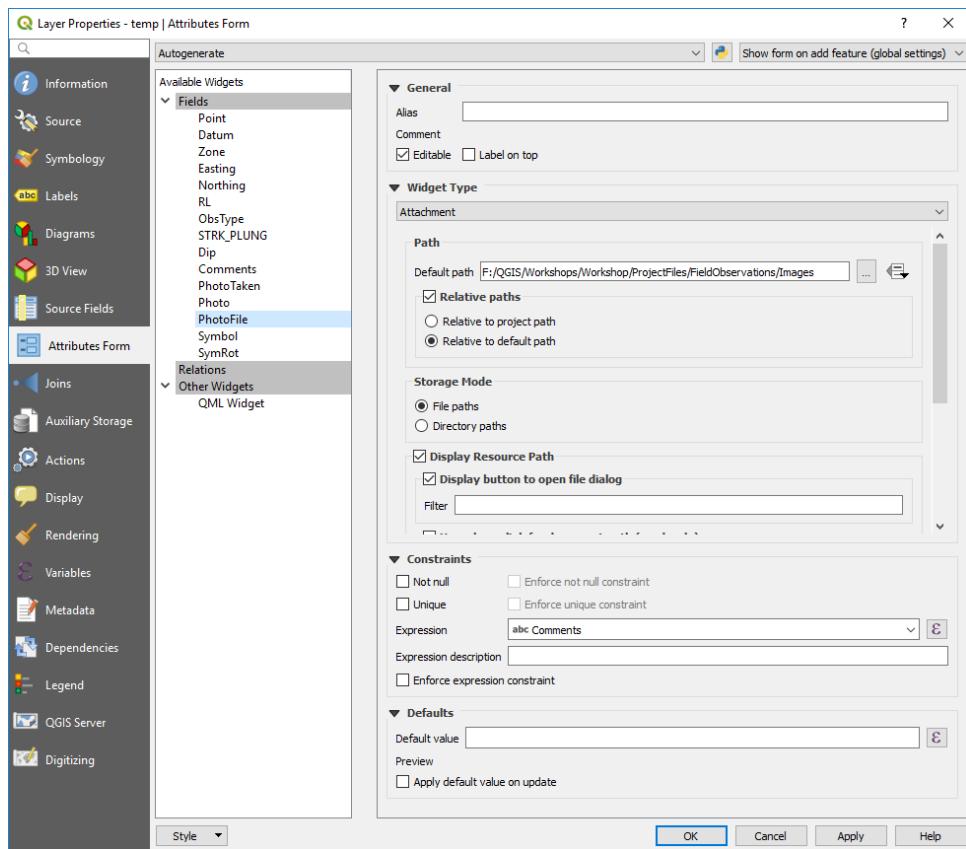


If you are importing photos via a different method, you will have to change some of the field values. For example, the default path to the image folder, tick “Relative paths” and “Relative to default path” option.

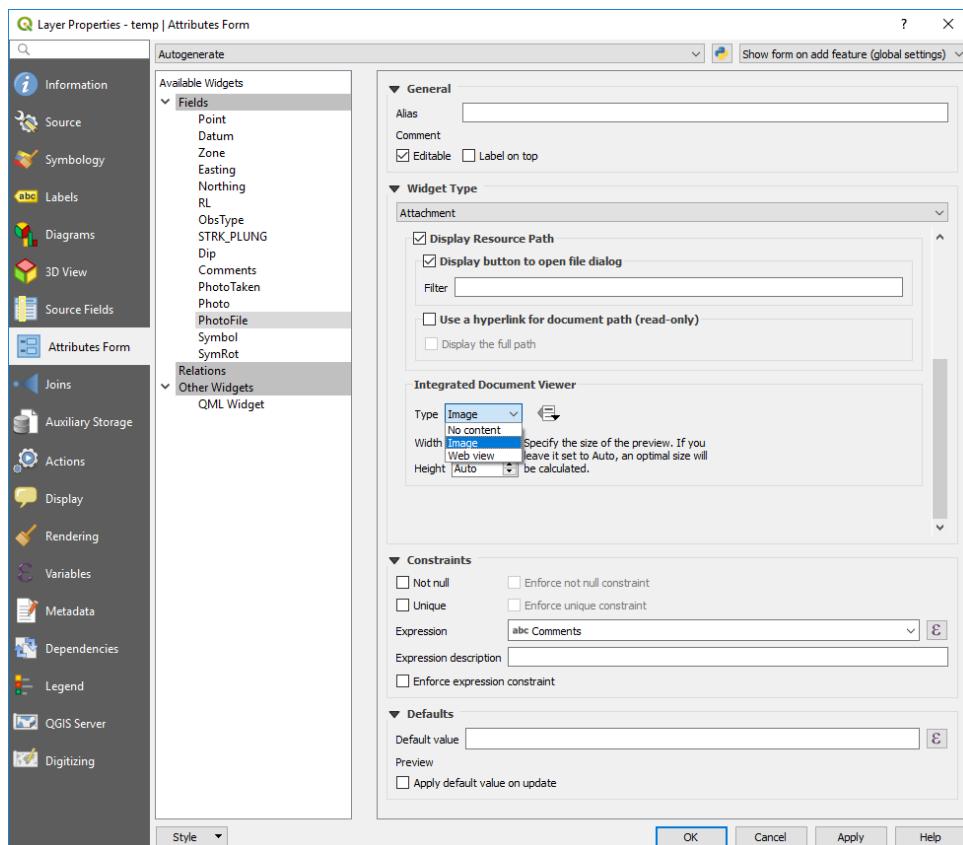
---

**Note:** The central dialog scroll down box can be difficult to locate but note the scroll bars on the right-hand side.

---



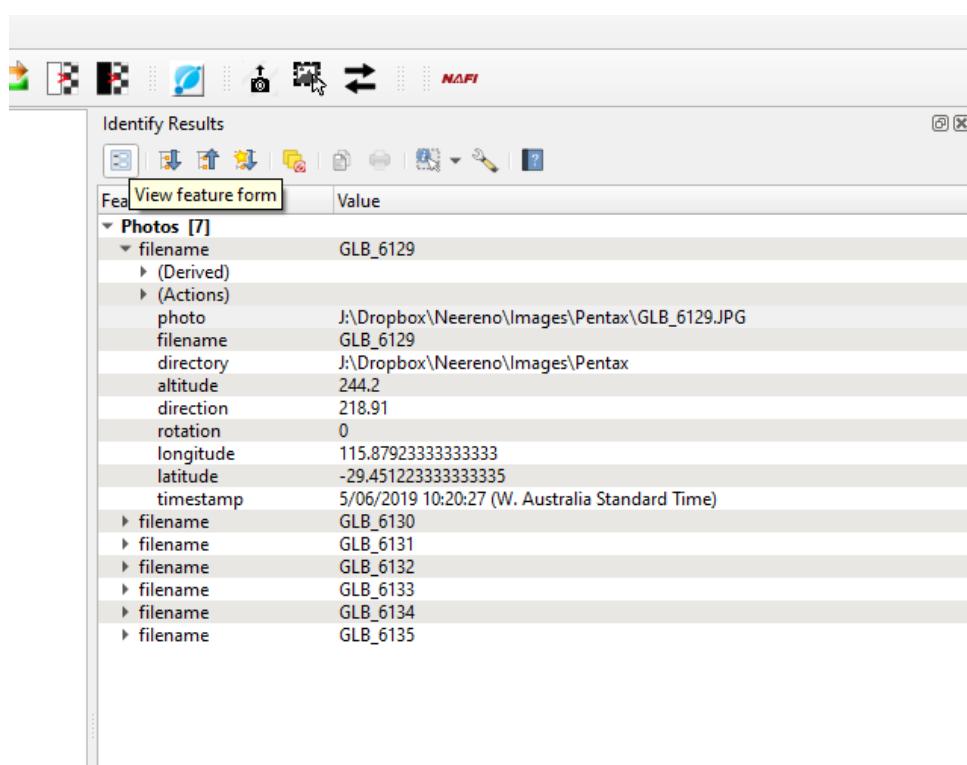
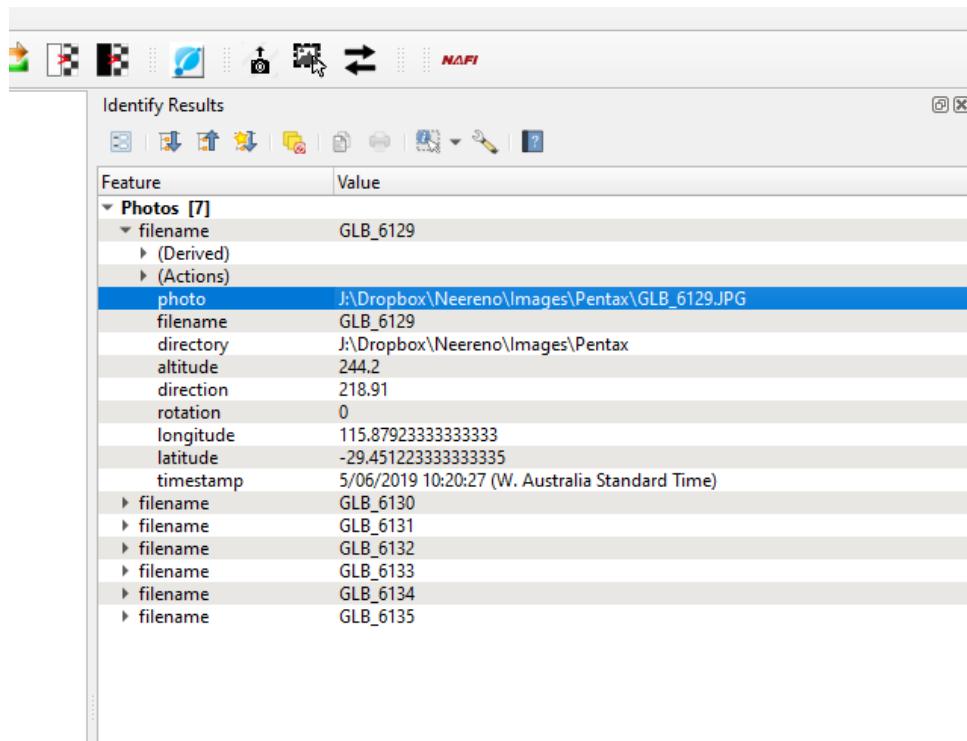
Scroll down the window the central part of the dialog box, past the “Storage Mode” to the “Integrated Document Viewer” section and select “Image”. Leave the sizes to Auto.

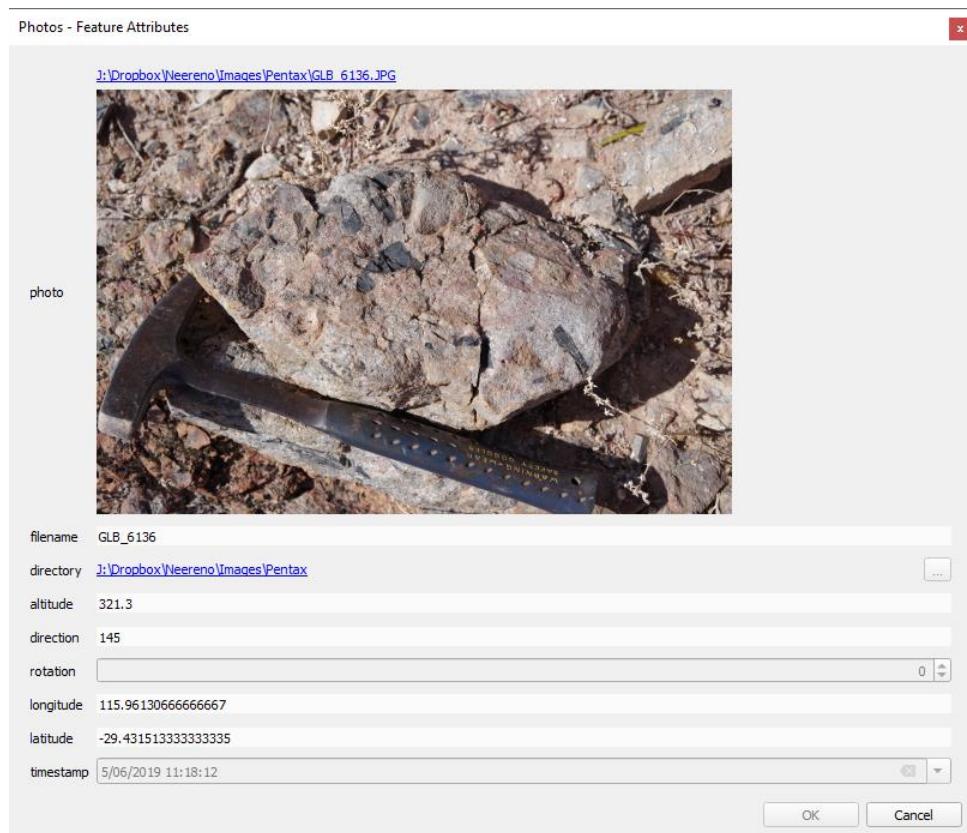


Apply the changes. In the map window, use the “Identify Features” icon to click on a point with a photo (this

should open an Identify Features dialog box), then in the identify features dialog box, highlight the point (if you have multiple points in the Identify Features dialog box), open the “form view” (top left icon in the Identify Features dialog box). This will open a new dialog box which may require re-sizing to see the image. If the point with the image is not at the top of the list, select the point and then open the form.

Once you have modified the Attribute Form, to display the photo, use the “identify” tool to click on the point (with the Layer highlighted in the Layers panel). If there is more than one point selected, QGIS will display the “identify Results” window showing the various points selected. Highlight the photo point you wish to display and then use the “View Feature Form” icon to show the information for that point and the photo. The form can be re-sized to enlarge a photo display.





This method of displaying photos can also allow you to display the comments for example that accompany an image.

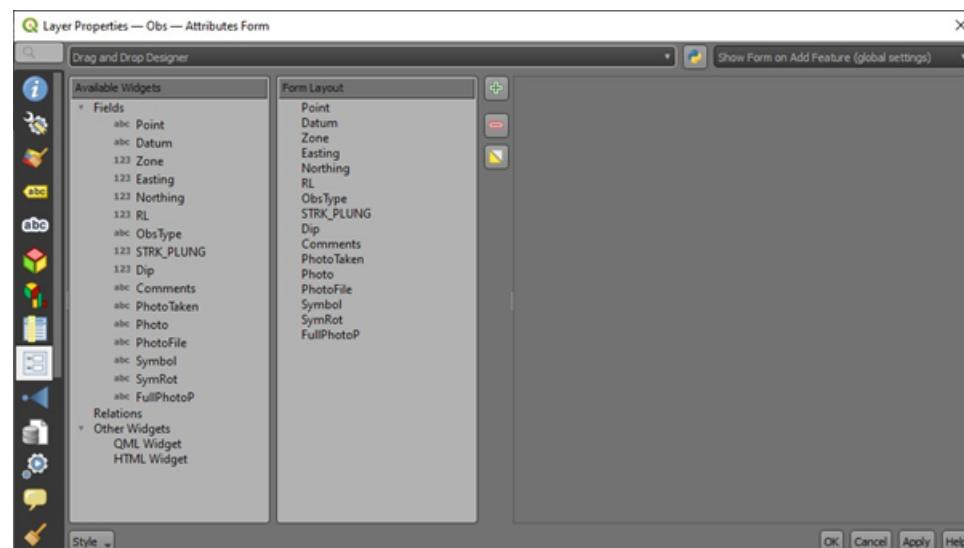
---

**Note:** This link is saved with the project and not in the layer properties.

---

### 7.2.3 Forms for Improved Viewing Photos Using the File Widget and Tabbed Pages

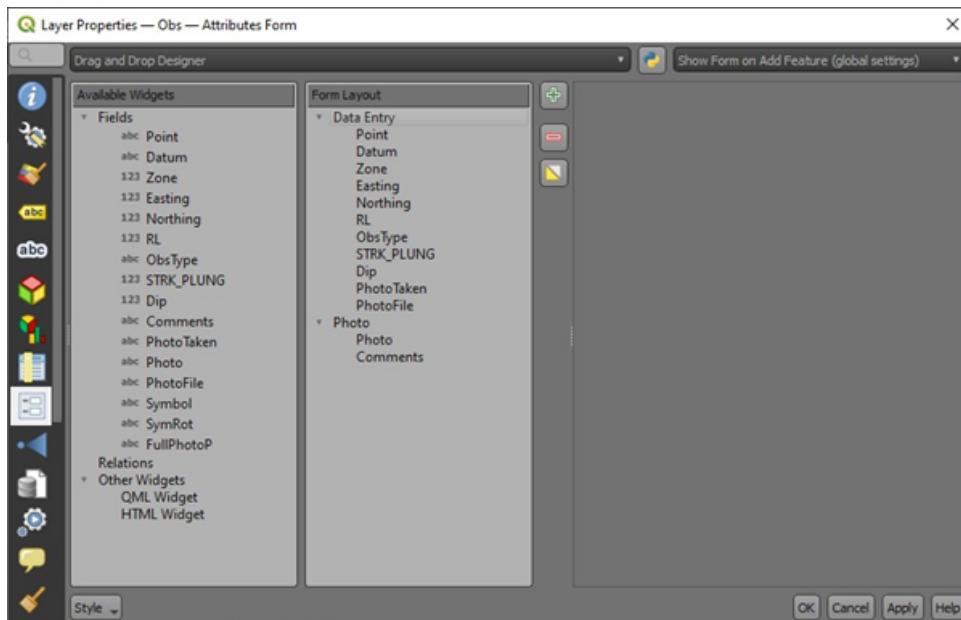
You can display photos and data in tabs using a widget in Layer Properties > Attributes Form. Select the “Drag and Drop Designer” option from the top combo box.



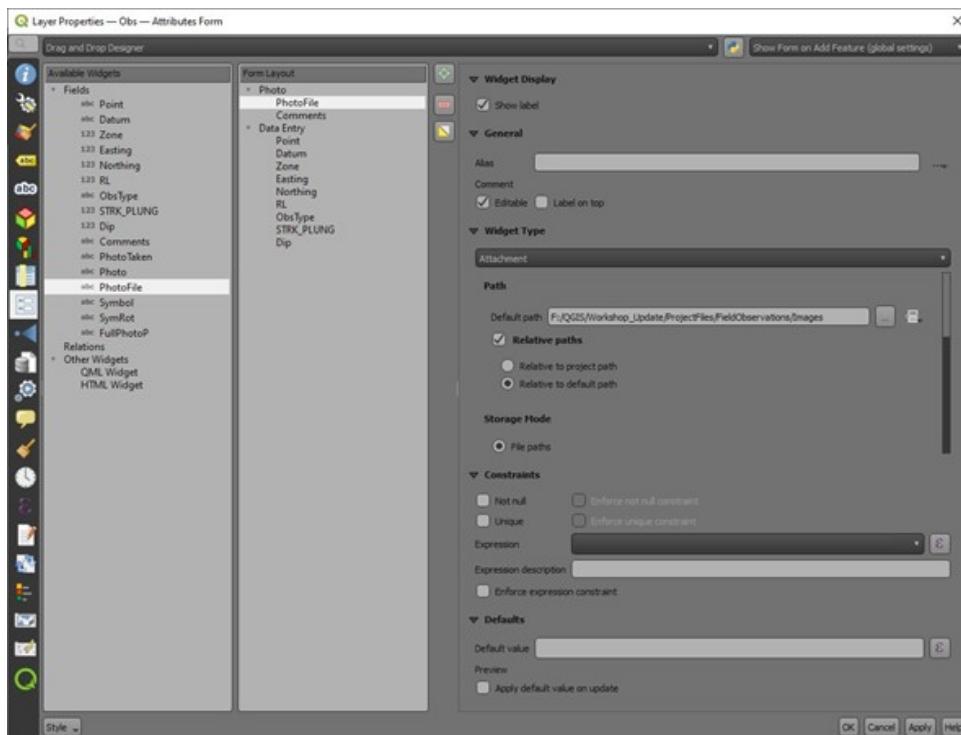
Using the green plus symbol, create two new “Container” items - “Data Entry” and “Photo”. Drag the “Photo”

and “Comments” into the “Photo” item (by click hold and drag over the item name) - this will display the image with the comments. Drag the other fields into the “Data Entry” item - you can remove fields by using the red minus button.

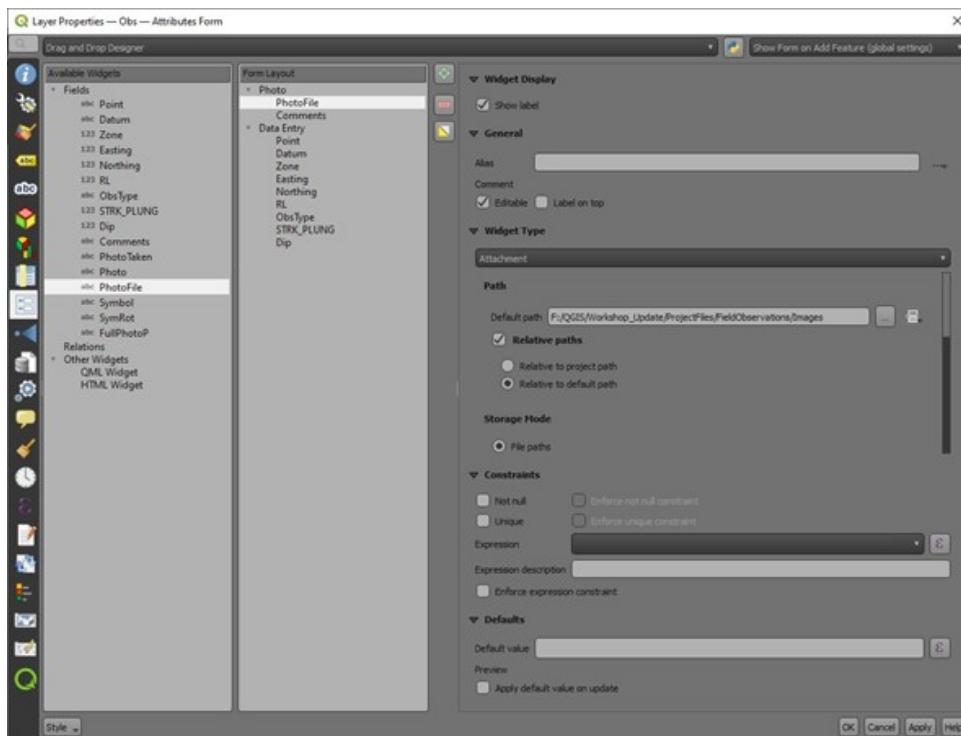
This will result in a tabbed window opening where we can switch between the data and the photo and makes it easier to see the photo. This works well in QField on a tablet device where space is limited.



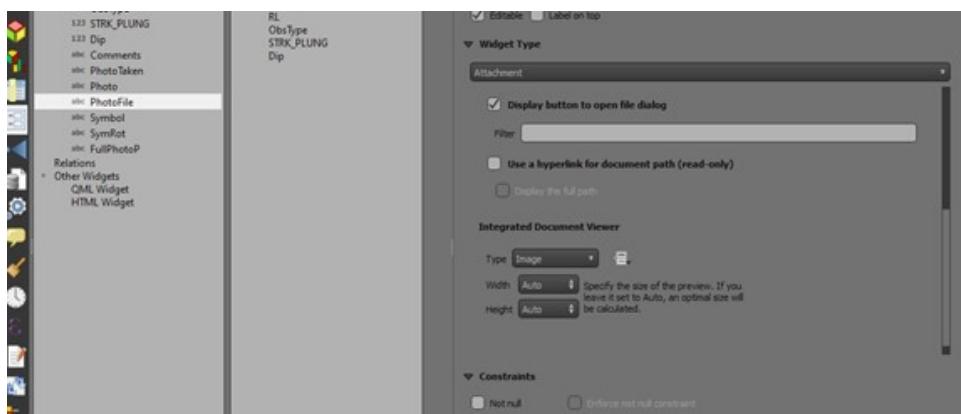
Select the field with the file location, e.g. “PhotoFile” field, then change the widget type to “Attachment”. Enter the default path to the image folder, tick “Relative paths” and “Relative to default path” option. Note the central dialog scroll down box can be difficult to locate but note the scroll bars on the right-hand side.



Scroll down the window the central part of the dialog box, past the “Storage Mode” to the “Integrated Document Viewer” section and select “Image”. Leave the sizes to Auto.



Drag the “Photo” item under the “Data Entry” item. This will then open up the image by default.



Apply the changes. In the map window, use the “Identify Features” icon to click on a point with a photo (this should open an Identify Features dialog box), then in the identify features dialog box, highlight the point (if you have multiple points in the Identify Features dialog box), open the “form view” (top left icon in the Identify Features dialog box). This will open a new dialog box which may require re-sizing to see the image. If the point with the image is not at the top of the list, select the point and then open the form.

Note that you need to save a new style file to remember these settings.

If there is more than one photo/point at the location, you need to select the point in the “Identify Results” window and hit the “open feature form icon in the top left-hand side of the Identify Results window.

Identify Results

Feature	Value
Obs [2]	
Point	GB05
(Derived)	
(Actions)	
Point	GB05
Datum	GDA94
Zone	50
Easting	397643
Northing	6741345
RL	305
ObsType	Joint
STRK_PLUNG	25
Dip	45
Comments	Breccia, smaller clast size, angular clasts of meta...
PhotoTaken	Y
Photo	#5834
PhotoFile	Carramar\05834.JPG
Symbol	NULL
SymRot	NULL
FullPhotoP	NULL
Point	GB05

GR1

Obs - Feature Attributes

Photo	Data Entry
	
PhotoFile	Knyarra\05834.JPG
Comments	Aboriginal stone workshop area, fgr basaltic rocks worked shards

OK Cancel

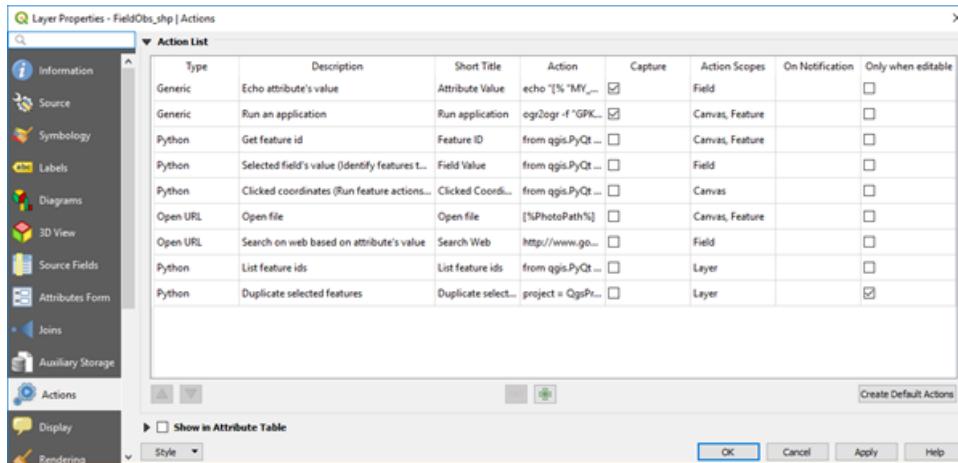


This method of displaying photos allow you to display the comments for example that accompany an image.

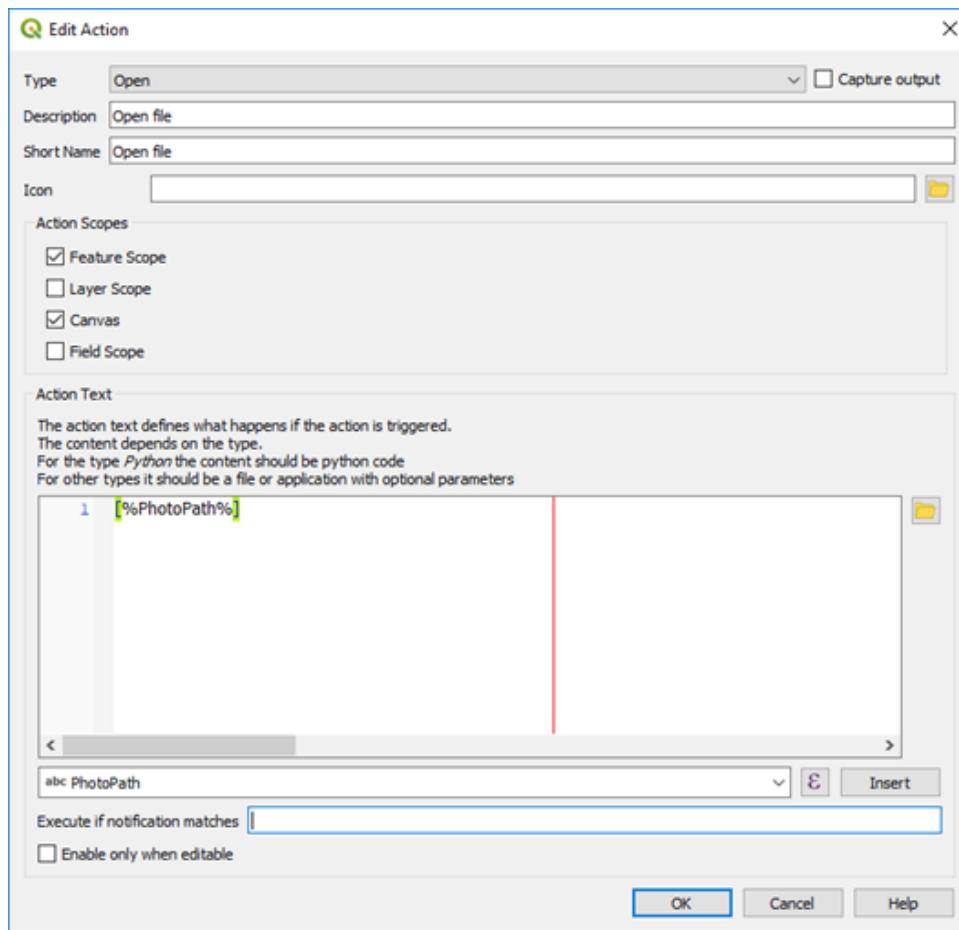
**Note:** Note this link is saved in the layer properties but only if you **save the style**.

#### 7.2.4 Viewing Photos by the Action Tab

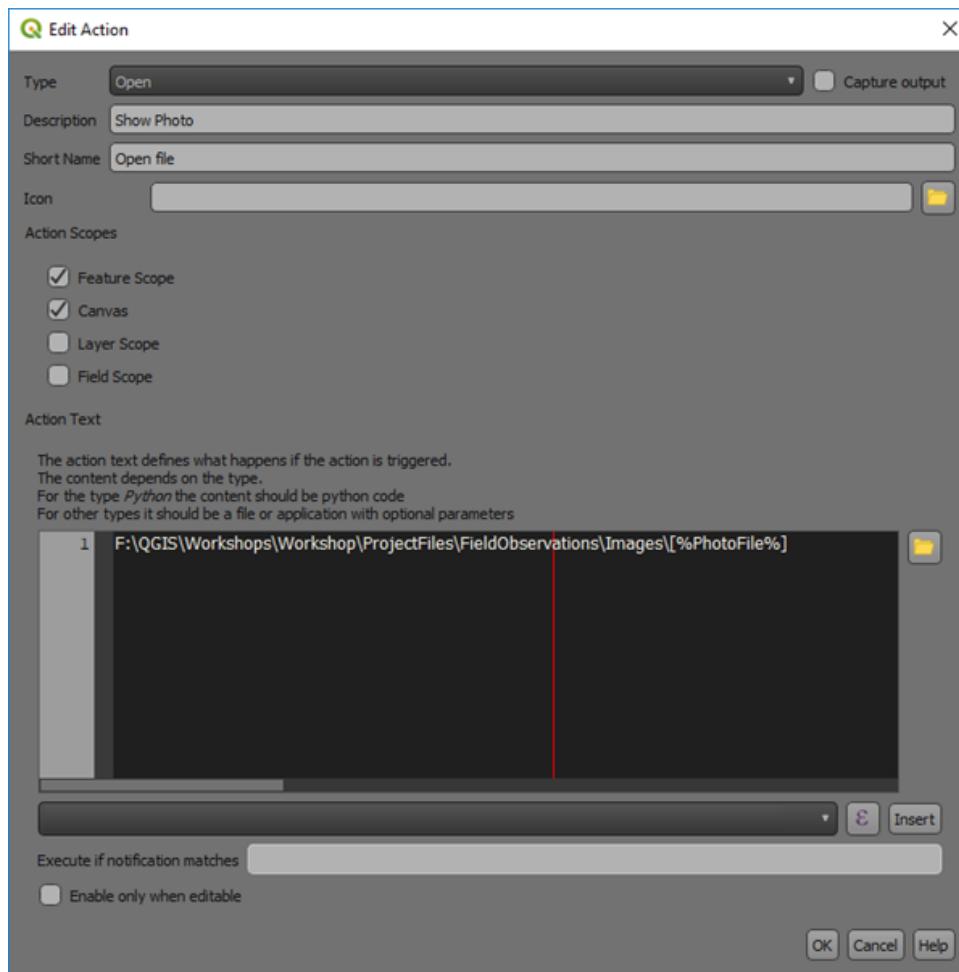
The third method to display photos is to use the Action option, open the Layer Properties of the layer and select the Action tab. Double click on the Open URL - Open File option.



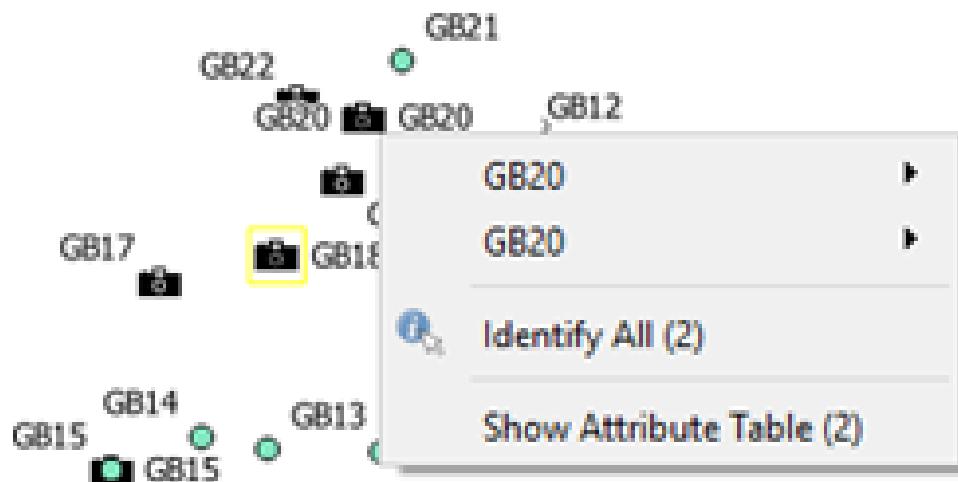
This will open the dialog box shown below.



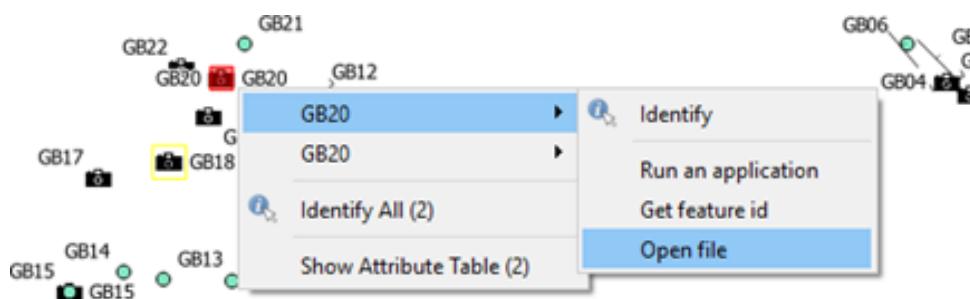
In the dropdown box near the bottom of the box, select the field with the photo location and click “Insert” to put the path into the Action Text window. Use the Windows file explorer to navigate to the directory that holds the photos, copy the path and paste it in front of the square brackets that holds the photo file name (as shown in the image below).



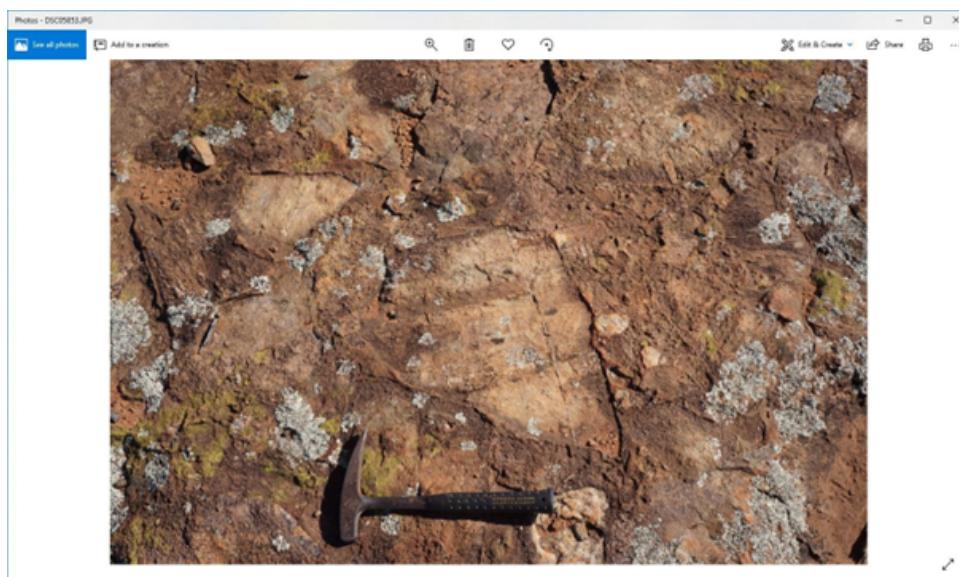
With the “Identify Features” activated for the cursor, right click on a point with a photo and the following will be displayed over the point.



Note there are two photos at this location.



Select the “Open File” option and the photo will be displayed.



### 7.2.5 Opening pdf attachments

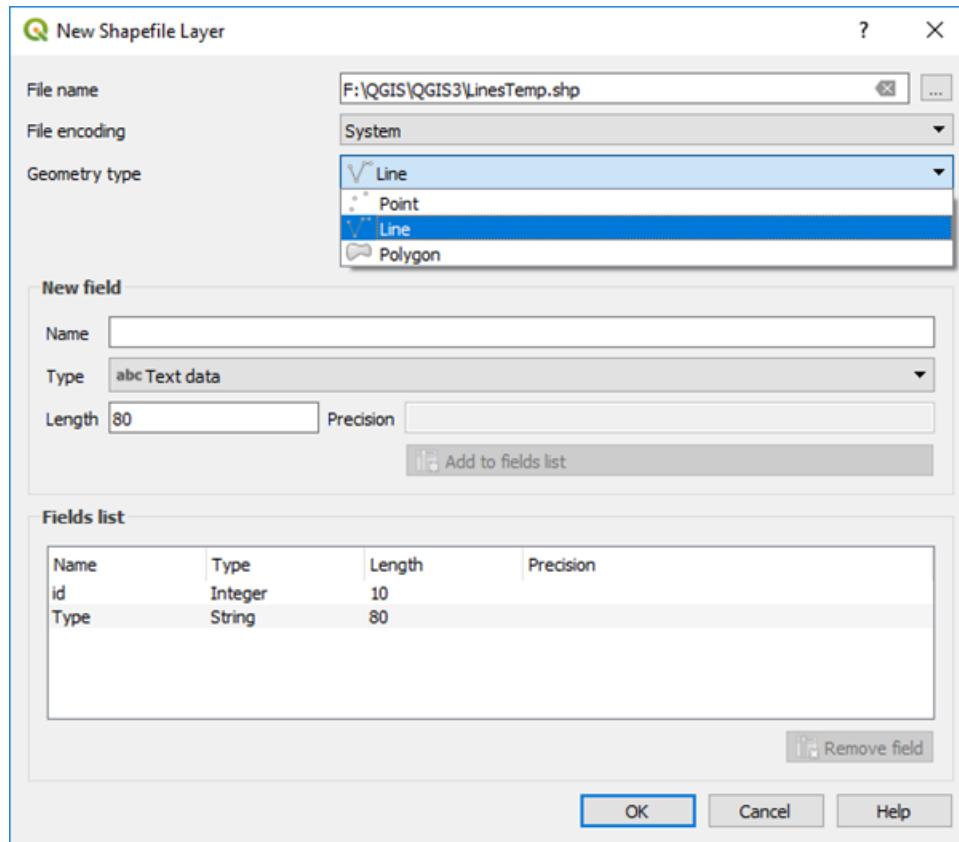
To open a pdf attachment, such as a report linked to a point, the action must include the executable file.

Add the path to the executable, e.g. ‘C:\Program Files (x86)\Adobe\Acrobat Reader DC\Reader\AcroRd32.exe’

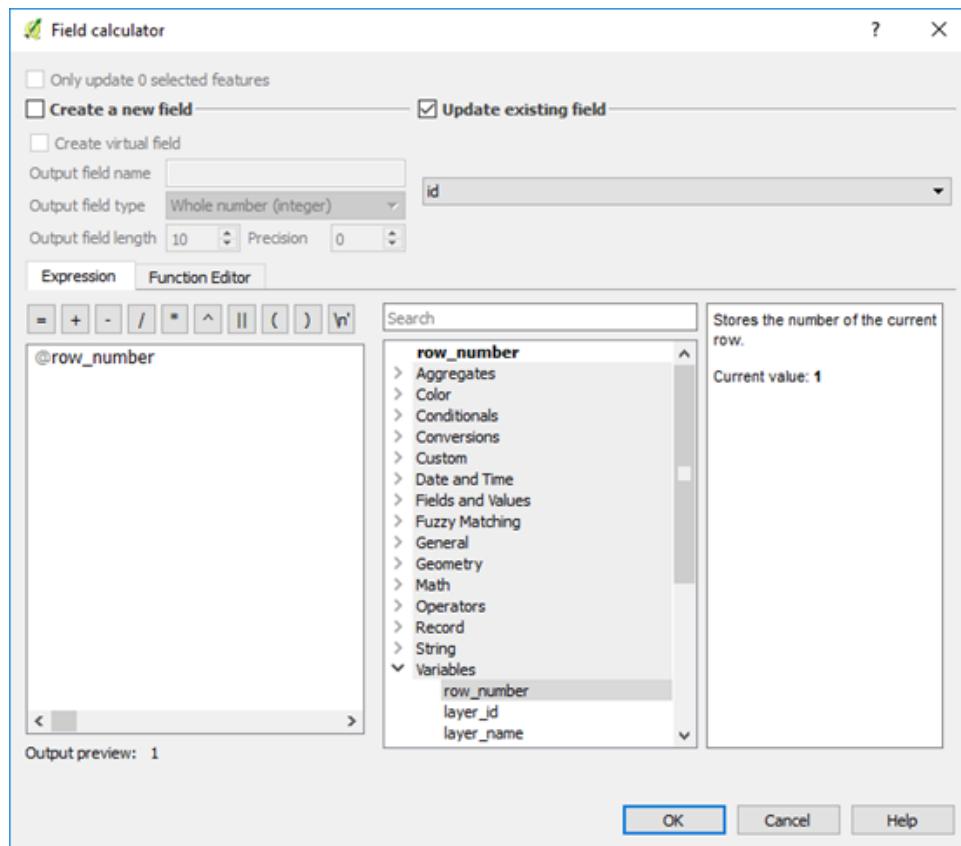
## 7.3 Line Data

Line data includes such items as contacts, faults and trend lines and are usually plotted on aerial or satellite imagery overlays. Surface mapping data can be digitised by scanning in the hard copy photo overlay into QGIS (via raster registration) and tracing the linear features, or by direct digitising on screen using the field mapping data as a guide.

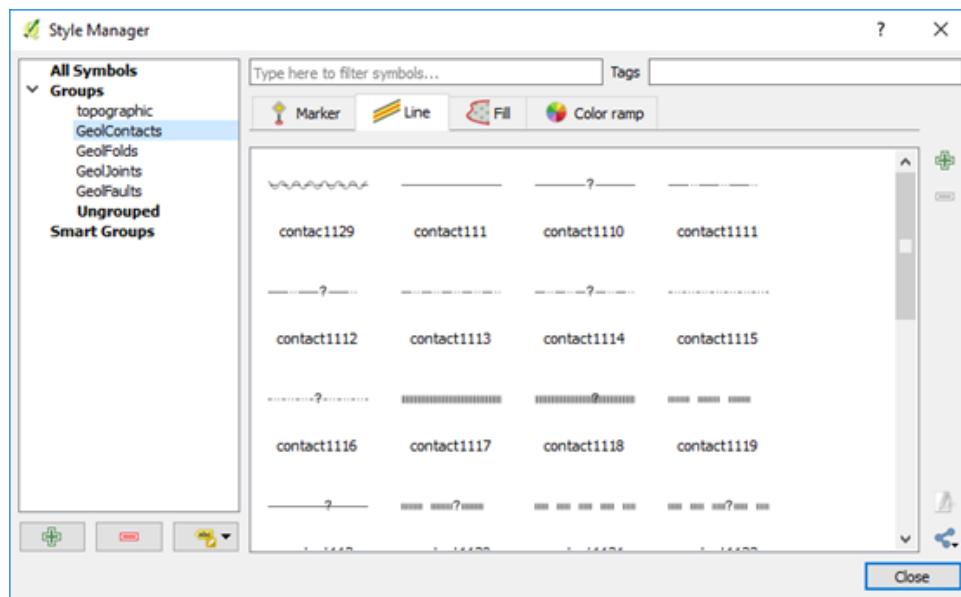
When creating a new vector layer to digitise the data, ensure the layer is the correct type, line type for example, has the correct map projection and add the necessary columns to be able to enter the relevant field data for each feature. Save the file with an appropriate file name.



If you are digitising into a shapefile, QGIS can automatically assign a unique id numbers for each line after the creation of a group of lines. Open the Layer Properties > Fields, select the id field and click on the field calculator icon and choose “Update existing field”, select the id field, select the “row number” operator in the Variables list. Now when you save the file it will allocate a unique id to each feature. Thanks to Chris Franklin for noting this feature. If you are digitising into a GeoPackage line file, the id field will be autonumbered.



Specific line styles can be added via the top menu Settings > Style Manager option. Geological line styles have been created as xml files and are imported using the “import” option, selectable from just above the Close button in the Style Manager dialog box. Import each style to a category, e.g. Contacts, so they are easier to locate.

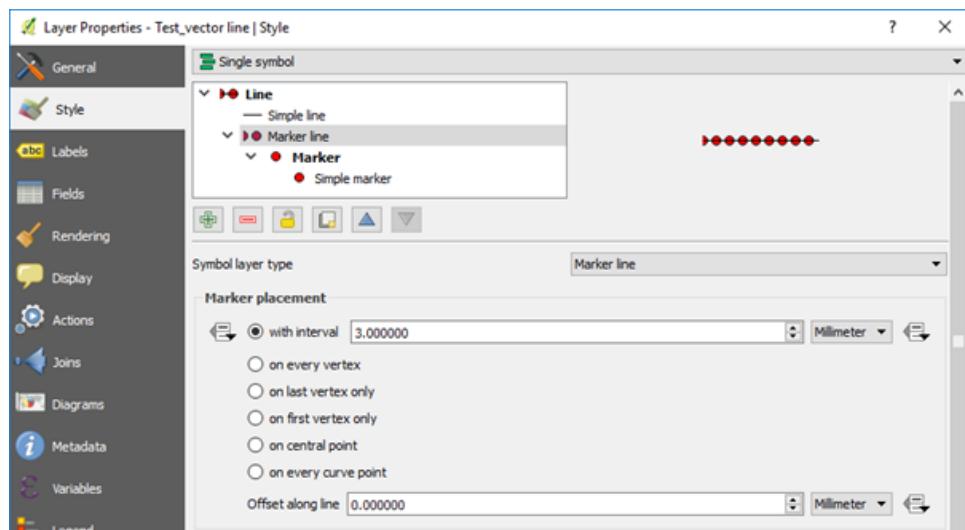


Contact the author, if you would like to download these style files for contacts, folds, joints, or faults which are based on the USGS symbol sets.

Note that the line direction can be reversed to get the tick symbols to plot on the opposite side of a line, e.g. fault ticks, using the “Reverse Line Direction” in the Advanced Digitising Toolbar (v3.4 or higher).

Line styles can also be created directly via the Style tab of the layer menu. Add an extra layer (using the green plus button) to combine lines and markers. There are numerous styles and options to choose from. Remember to save the style using a .qml or “Save as Default” option when finished editing the line style.

You can combine many line styles into the one vector line file, providing you have a column by which the lines can be classified, e.g. feature type “contact”.

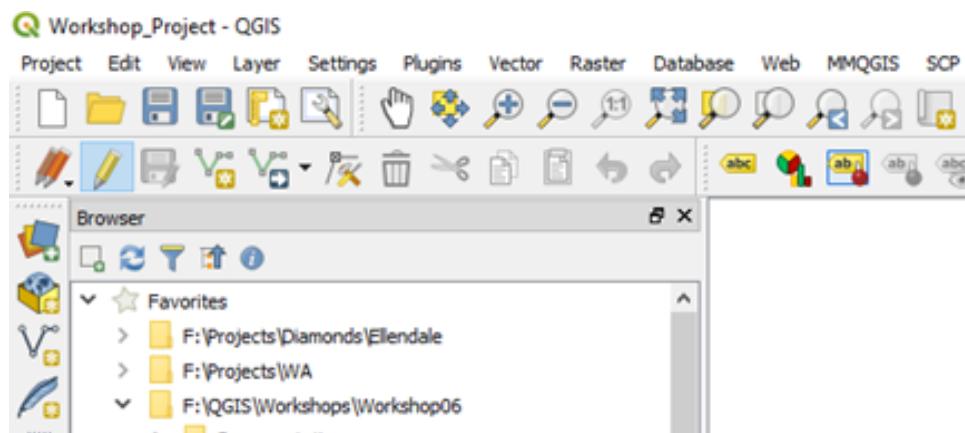


Lines can be edited by first highlighting the layer in the Layers panel and clicking the enable editing icon (pencil). A pencil symbol will then appear next to the layer being edited in the Layers panel. Remember to save your edits when exiting the edit mode. When the line is editable, there will be red crosses on the vertices. Click on the “node” tool (seventh button along from left, next to rubbish bin) then click near a vertex to highlight the vertices, select the vertex you want to move and simply click where you want to move it to. Note QGIS v3 uses “click-click”, not “click and drag” methodology. To add more vertices, hover over the line and click on the small red cross that appears. This will create a new point which can then be moved.

---

**Note:** See the [QGIS User Guide](#) for up-to-date information on editing.

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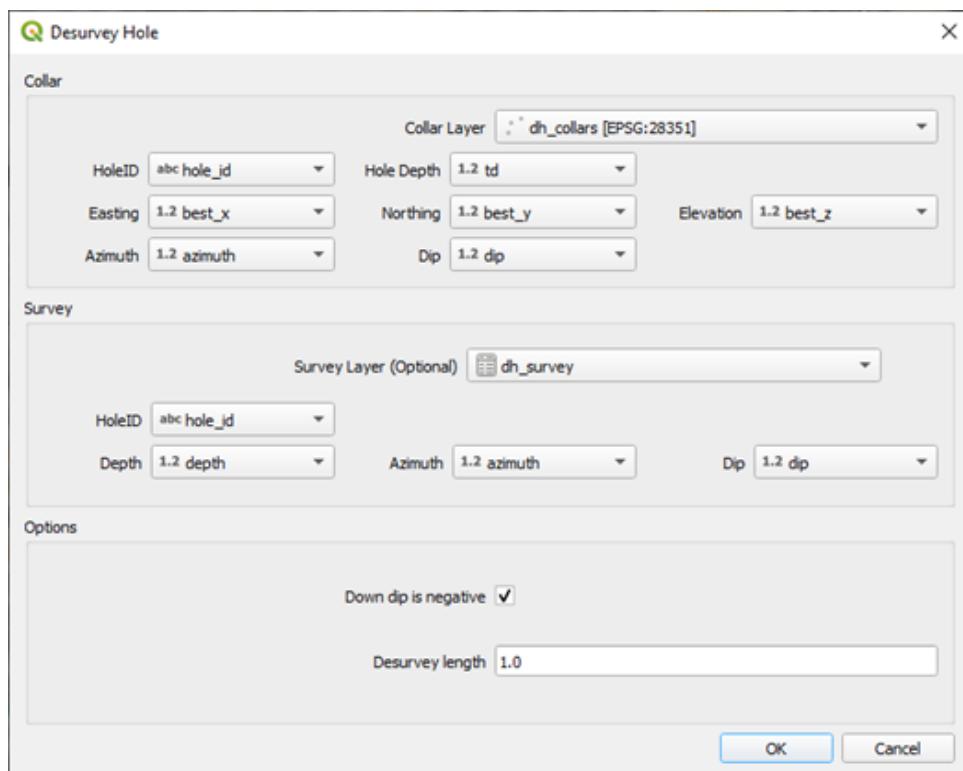
## 7.4 Plotting Drill Hole Traces and 3D Drill Data Display

There are two options to displaying drill hole traces on maps. One is to create the horizontal trace and use the “Shape Tools” plugin to plot the lines, or you can use the new “Geoscience” plugin. Both methods are described here.

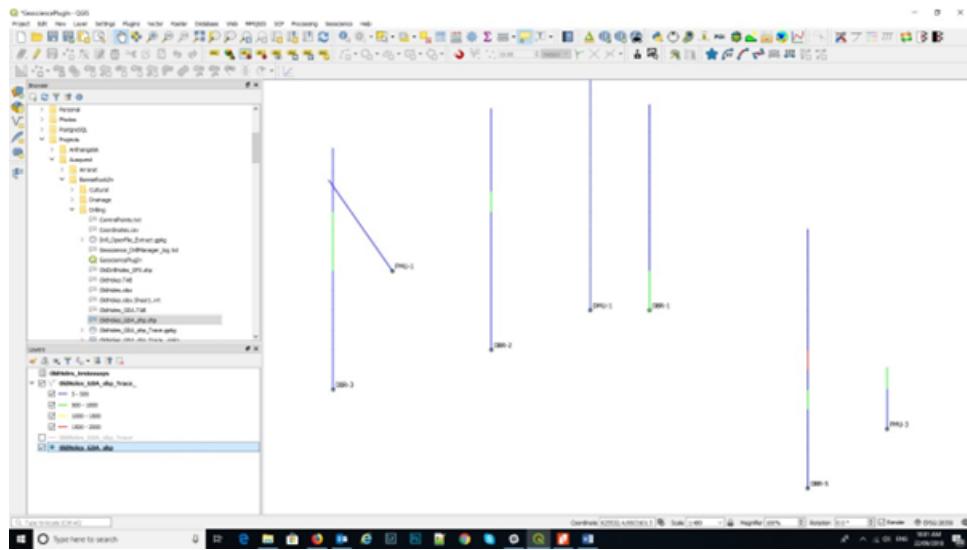
### 7.4.1 Geoscience Plugin

The “Geoscience” plugin (with thanks to Roland Hill) has allowed the plotting of drill hole traces and colour coding of the drill hole traces in QGIS easy. Cross sections can also be created. The drill set up screen allows you to select the collar and survey files. You will need to install the plugins in the Plugin Manager.

If your tables have commonly used field names, then the plugin will pick the fields. If you have collar elevations in both the collar file and drill hole survey file, make sure these values are the same, otherwise the points may not be plotted.



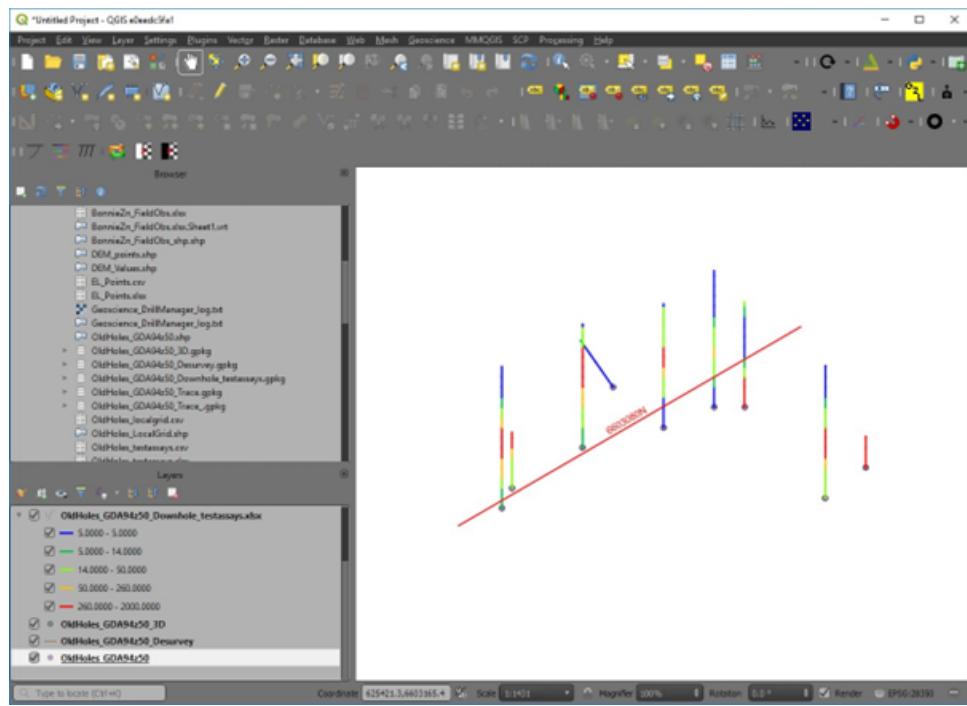
The Desurvey option calculates the 3D trace of the drill hole. The 3D coordinates of each sample are calculated when you “attach” the downhole data, like assays or lithology, to the drill hole trace. Top, bottom and mid-points of each downhole interval will be calculated in xyz coordinates. The data to be displayed down the drill hole trace needs to be imported as a non-spatial file with hole id, from, to and data fields. Down hole data can be assays, lithologies, or other data. If the downhole data fields are in a csv file format, make sure this is imported via the Data Source Manager > Delimited Text option so that QGIS interprets the correct field types, particularly for the from and to fields which must be numbers. The help menu for the plugin describes the workflow and a link to the [web page](#). Mid-point coordinates are calculated and can be downloaded using the downhole data output as a csv file for use in other programs like ioGAS or LeapFrog.



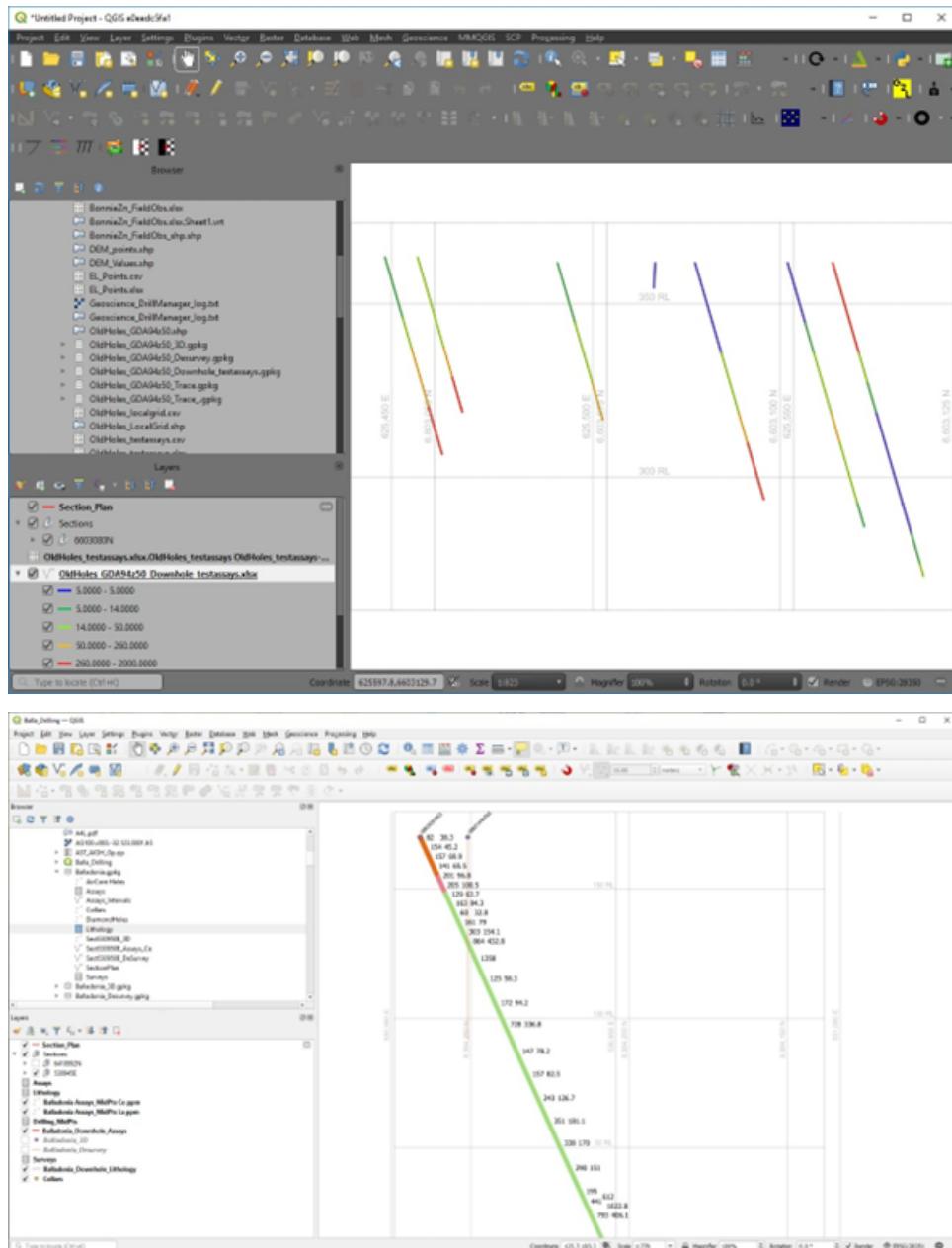
To enable labelling of assay results down hole, use the 3D mid-points of the assay intervals. This will then allow the display of multiple assay values by duplicating the assay -mid-point layer and choosing the data to be displayed. To display the lithology as a hole trace colour, make sure you include the lithology layer in the desurvey option, then use the symbology tab to colour by lithology (by categorise).

The drill hole traces (the desurveyed layer with the down hole data attached) can be coloured via the “Symbology” tab using any attribute. Note that when you import the downhole data, e.g. assays, make sure the “from”, “to” and assay values are recognised as numbers not text.

To create a cross section, use the “Section Manager” and using the “Use Map Canvas” and select the envelope width, draw the required section line.



The cross section will be created in a “new” location on the map. To get back to the collar positions, right click on the collars layer and “zoom to layer”.

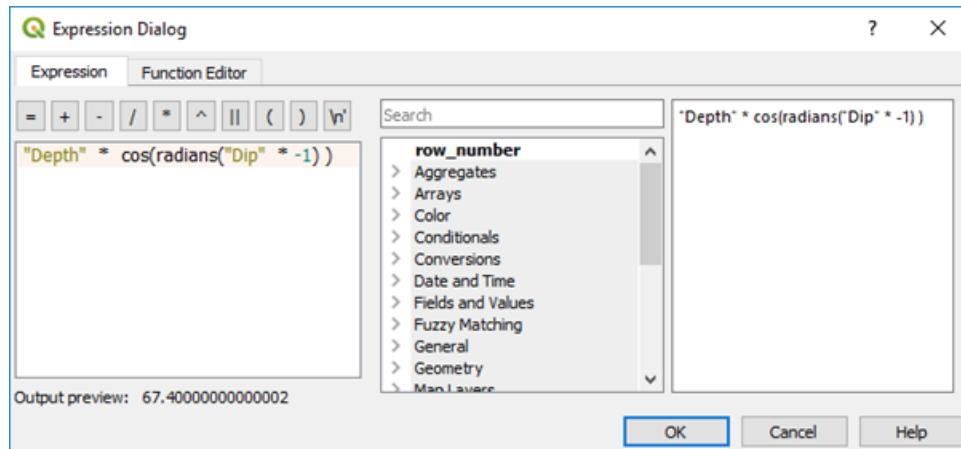


Cross section plot with the hole trace coloured by lithology and the assay values of two elements displayed using their mid-point locations.

#### 7.4.2 Alternative Way to Plot Drill Hole Traces on Plan

Surface drill hole traces can also be plotted on plans using the Shape Tools plugin. To plot drill hole traces, a collar file with collar coordinates, azimuth and horizontal projected distance columns are required. The horizontal distance - trace length - is calculated using the following formula;

$$\text{Trace length} = \text{hole length} * \cos(\text{radians}(\text{dip}))$$

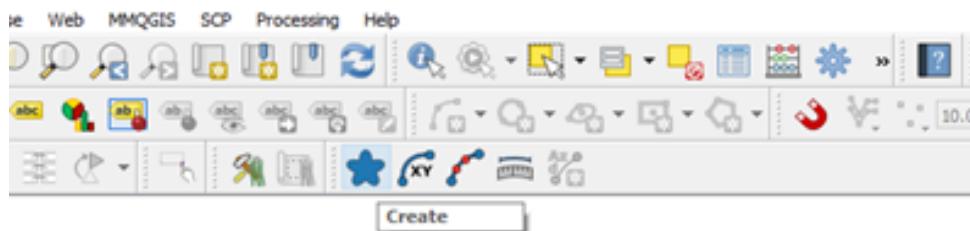


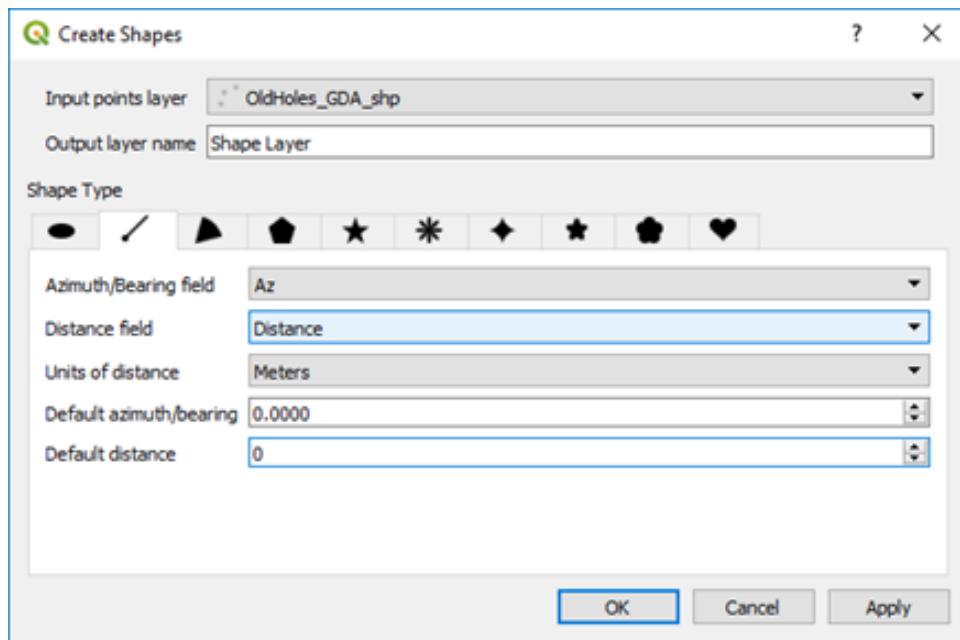
**Note:** If down dip is negative, multiply the dip by -1 (as in the above example).

The screenshot shows the attribute table for the 'OldHoles\_GDA.shp' layer. The table includes columns for HoleID, Datum, Zone, East, North, Az, Dip, Depth, LocalEast, LocalNorth, and Distance. A formula bar at the top of the table preview area contains the expression `"Depth" * cos(radians("Dip" * -1))`. The first few rows of data are as follows:

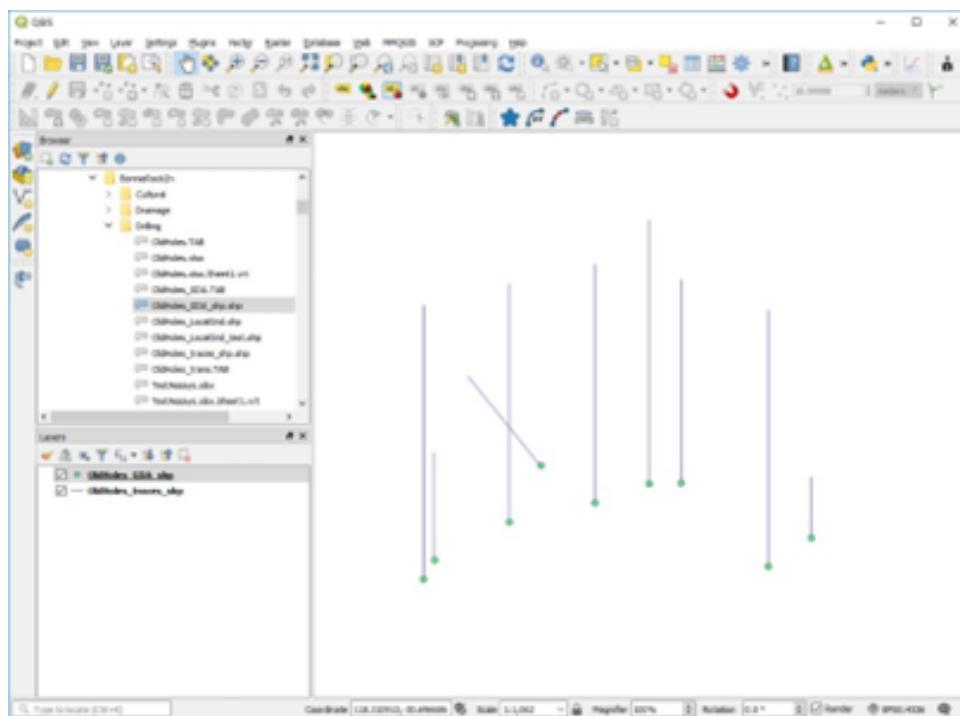
HoleID	Datum	Zone	East	North	Az	Dip	Depth	LocalEast	LocalNorth	Distance
1 DMU-1	GDA	50.000...	625555.00...	6603090.00...	360.00...	-60.00...	134.80...	10125.00...	9450.00...	67.40
2 DMU-2	GDA	50.000...	626030.00...	6603049.99...	180.00...	-60.00...	177.15...	10600.00...	9410.00...	88.58
3 PMU-1	GDA	50.000...	625504.99...	6603099.99...	325.00...	-60.00...	56.000...	10075.00...	9460.00...	28.00
4 PMU-2	GDA	50.000...	625454.99...	6603049.99...	360.00...	-60.00...	55.000...	10025.00...	9410.00...	27.50
5 PMU-3	GDA	50.000...	625629.99...	6603059.99...	360.00...	-60.00...	31.000...	10200.00...	9420.00...	15.50
6 DBR-1	GDA	50.000...	625570.00...	6603090.00...	360.00...	-60.00...	104.00...	10140.00...	9450.00...	52.00

Using the Shape Tools plugin (from icon task bar) select the Create icon and the Line tab.





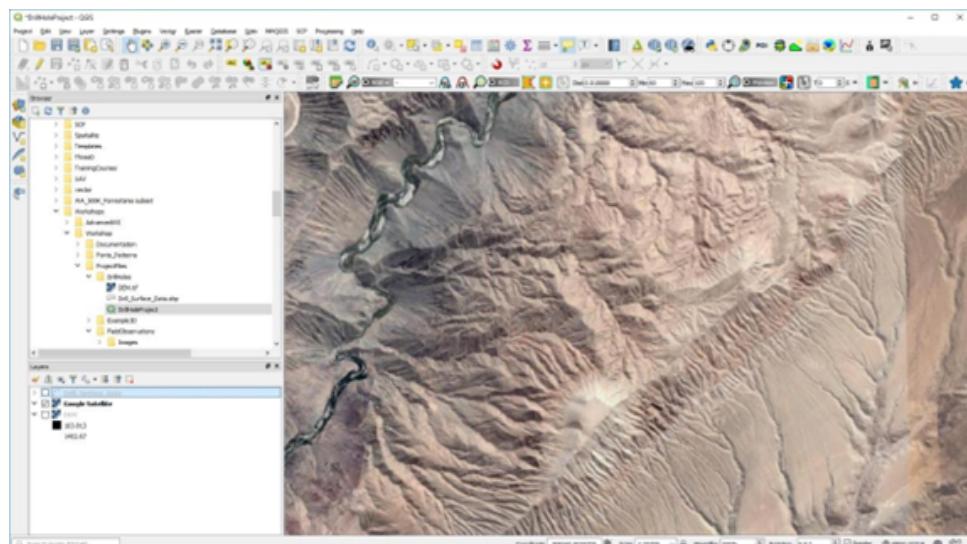
Select the Azimuth column for the hole azimuth and the distance field for the length of the hole trace. Check the units of distance is in metres. The result should look something like below with the hole traces created in a new virtual file - remember to save it with a relevant name.



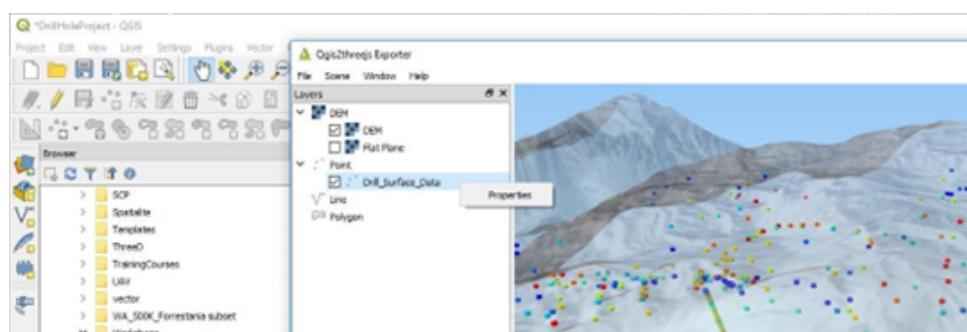
### 7.4.3 Displaying Drill Hole Traces in 3D

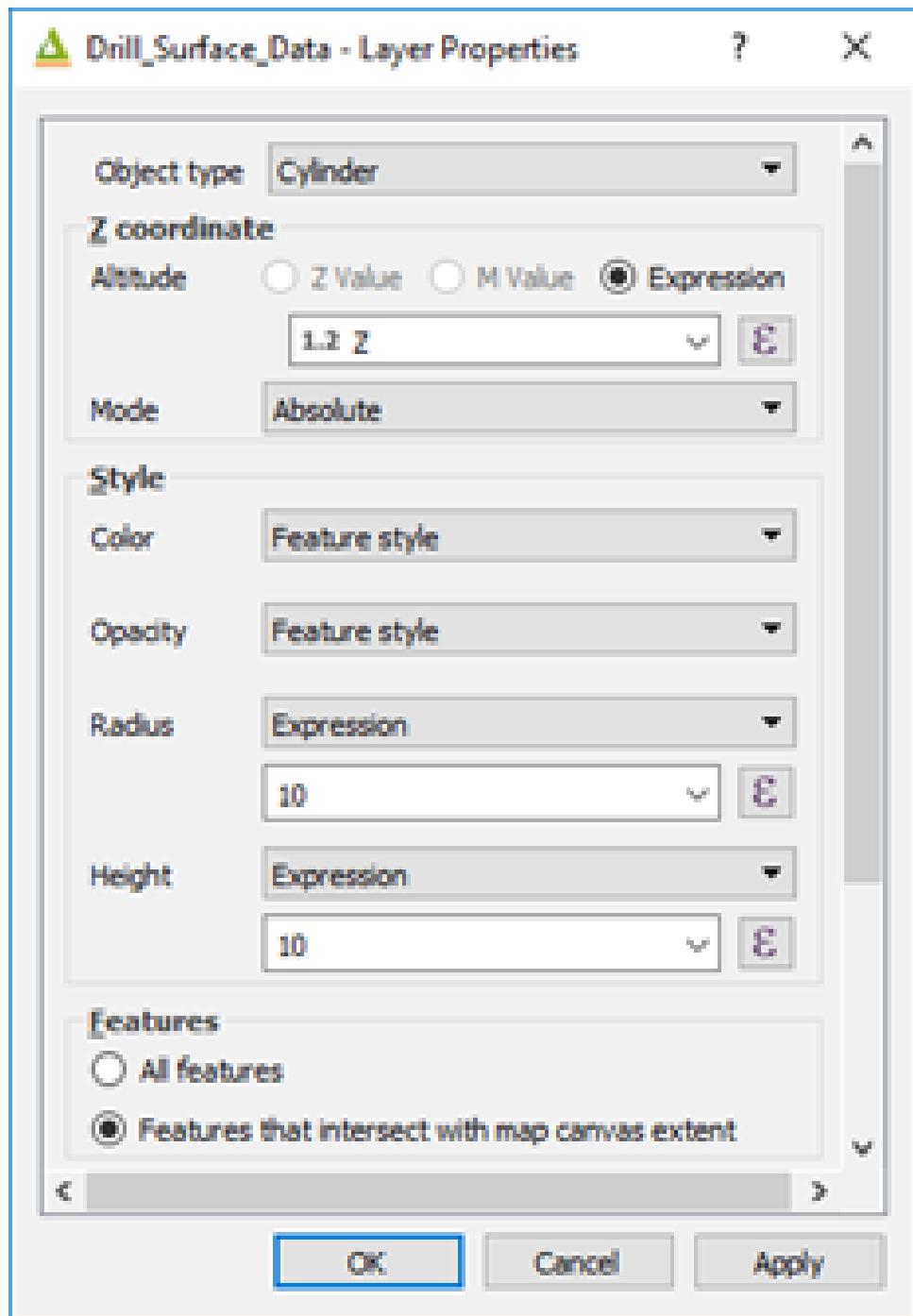
It is also possible to display drill hole data in 3D using the “QGIS2threejs” plugin. All that is required is to have the 3D coordinates for the sample points to be calculated. This is a simple display option and will hopefully be superseded with the development of the drill hole and cross section module planned for the future (“OpenLog” plug-in being developed by Oslandia). The QGIS2threejs plugin displays the centre points in XYZ coordinate space. The sampling data can be coloured according to any attribute in the file, e.g., assay values of Cu.

To display the downhole data, the 3D coordinates are required for the drill hole traces. In the example below, the XYZ mid-points have been calculated for assay intervals. In the main map window, then DEM, Google Earth satellite image and the file containing the 3D coordinates of surface and drill hole samples have been loaded. The DEM layer and sample layer are not displayed (but loaded).

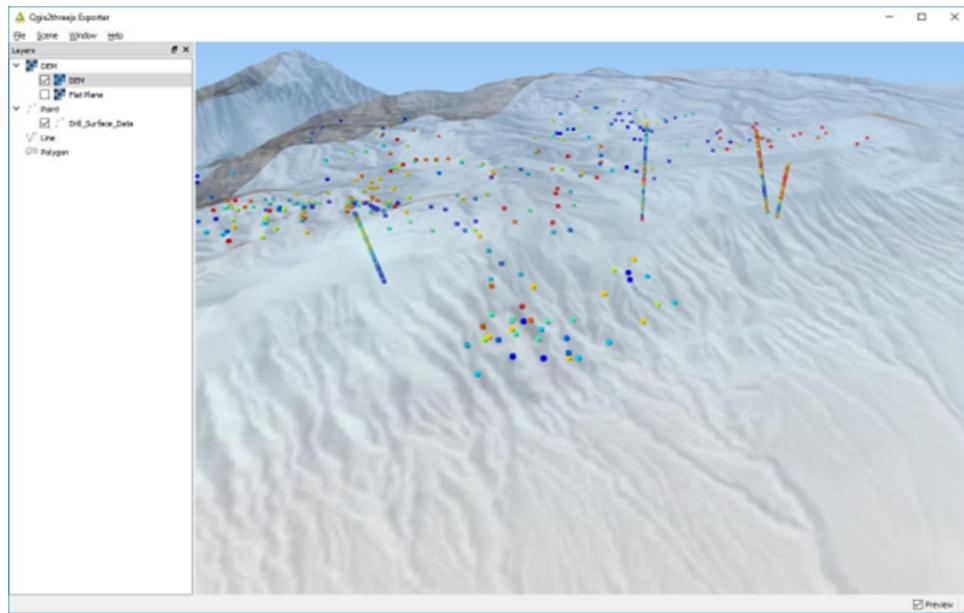


When opening the QGIS2threejs plugin, select the DEM for the elevation and right-click on the samples layer to select the z coordinate.





The 3D image can then be rotated and tilted as desired. The surface satellite image has been set to 30% transparency to be able to see through the surface.

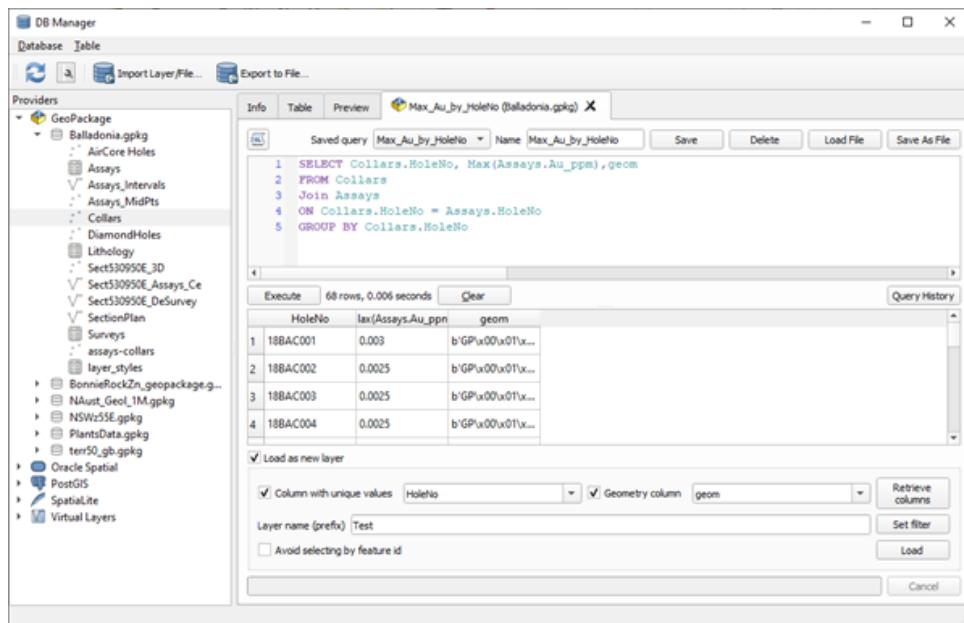


Always remember to save your project regularly.

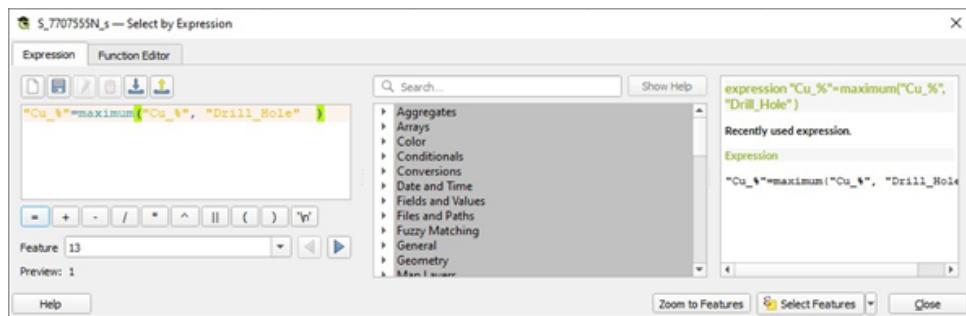
#### 7.4.4 Extracting Maximum Values for Drill Holes

This can be done at least two ways. The first way is to calculate the drill hole statistics and group by drill hole (algorithm “Statistics By Category”). This method requires coordinates for all assay points.

The second method is to use an SQL query on a GeoPackage file. Save the collar file and the assay file into a GeoPackage, then use the DB Manager to connect to the GeoPackage. Open the SQL Window, second icon from left, and then run the SQL query as shown below. Do not forget to add the “geom” column to the query so the resulting layer can be plotted. Each point will have the max value attached.

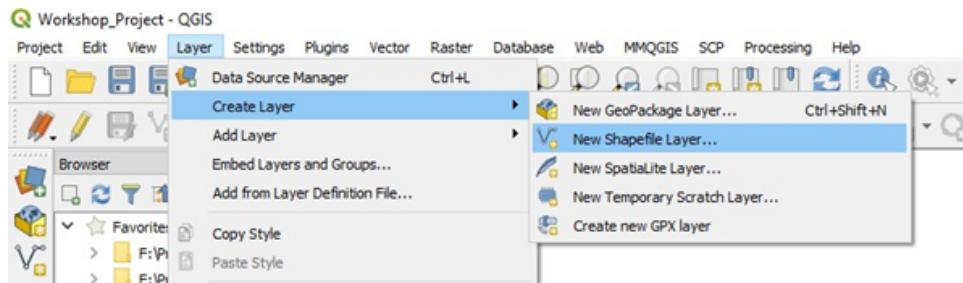


To select the maximum assay value by drill hole, use the “maximum” function.

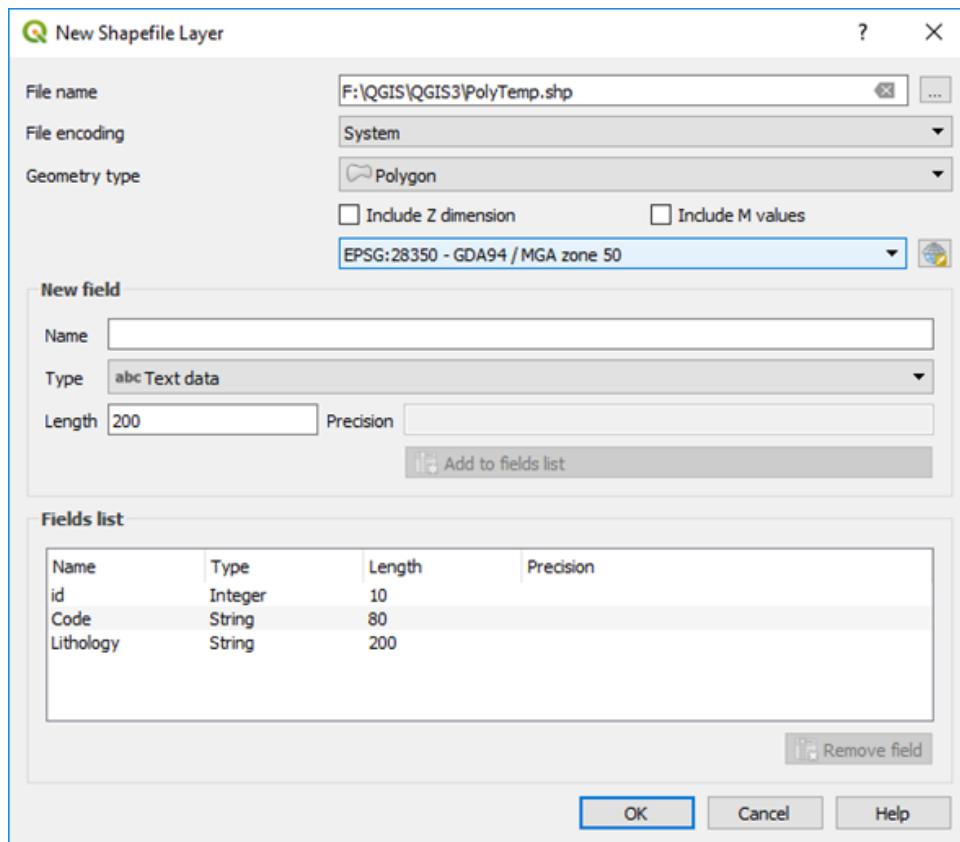


## 7.5 Polygon Data

Polygon data is added by creating a new polygon layer ( Layer > Create Layer > New Shapefile Layer or New GeoPackage Layer), selecting type “polygon”, set the projection information and enter the additional fields for the polygon file. Note that if you are creating a GeoPackage file, QGIS will auto-number every new feature when digitising.



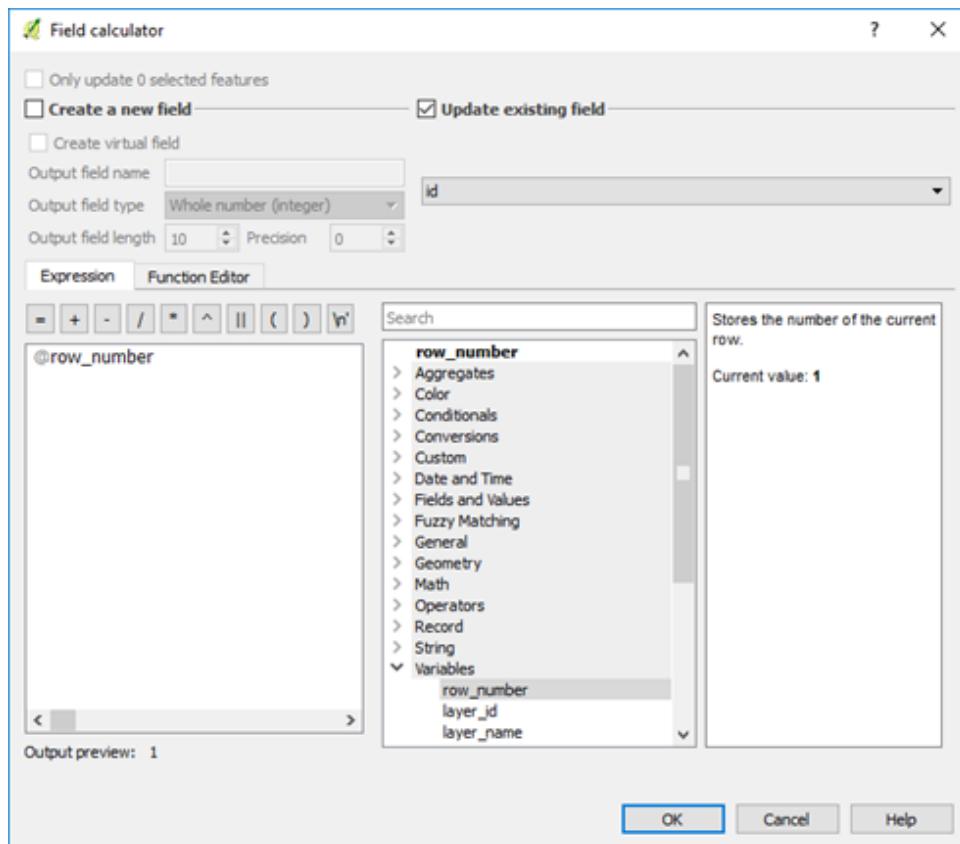
The additional columns might hold data such as geological code, geological descriptions, etc. Remember to select the correct field type (string, number, and precision, etc) and, remember that field names are limited to a length of 10 characters in shapefiles - but not in GeoPackage files.



When creating new objects in a shape file, every new polygon should be assigned a unique “id” number. If you keep these unique, then it is easier to select and alter polygons which can be then selected by their id. Note that digitising into a GeoPackage file will automatically number the id field.

To add a new polygon, highlight the polygon layer in the Layers panel, and toggle the editing button (pencil icon). Numerous polygon options are available - see the second row of menu. To add a new polygon, use the Add Polygon Feature icon. Hover over each icon for an explanation of the icon actions. If not all the digitising and advanced digitising options are not show, check the top menu View > Toolbars options.

QGIS can also assign a unique id numbers for each polygon in a shape file after digitising is compete. Open the Layer Properties > Fields, select the id field and click on the field calculator icon and choose “Update existing field”, select the id field, select the “row number” operator in the Variables list. Now when you save the file it will allocate a unique id to each feature. Thanks to Chris Franklin for noting this feature.

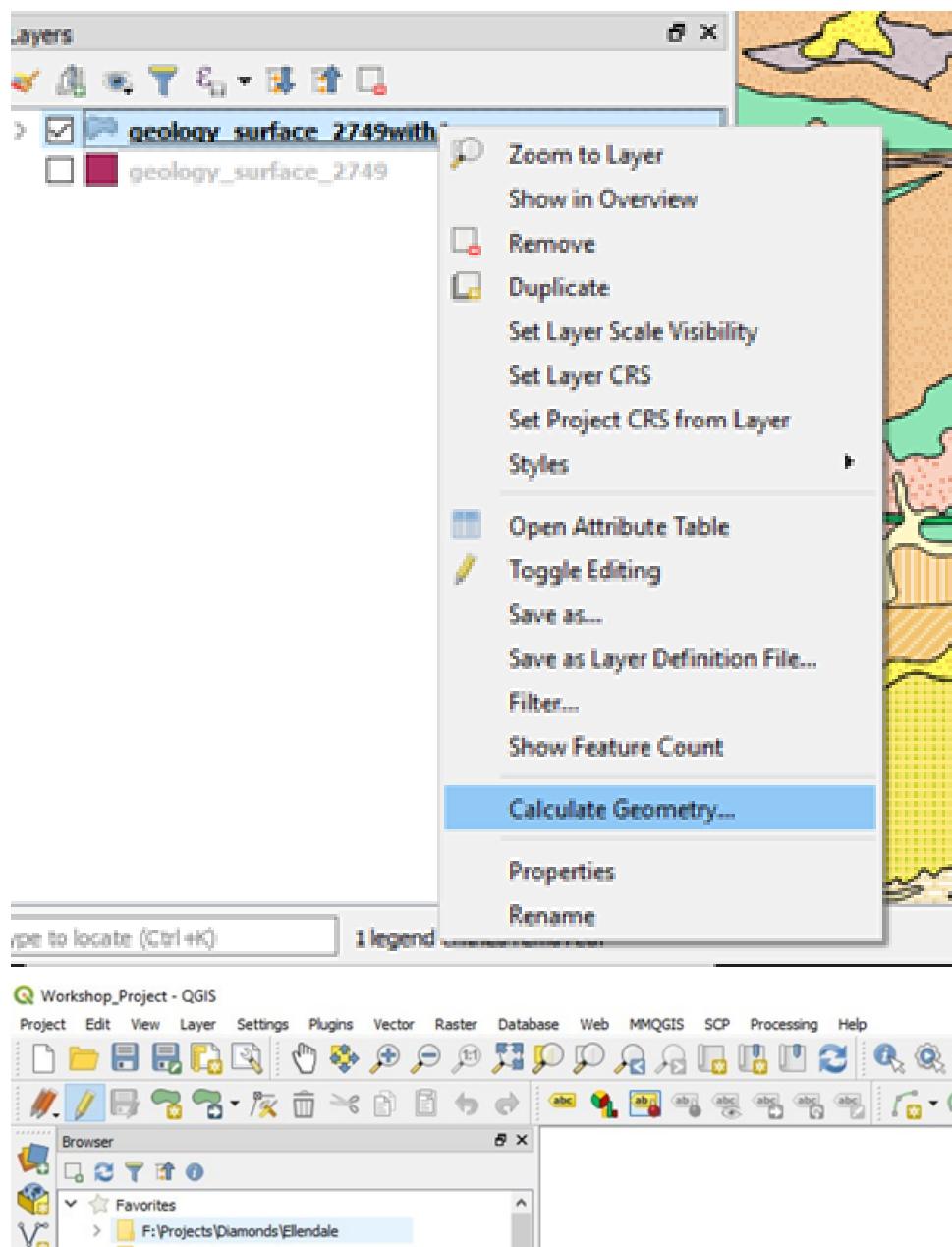


If you want to calculate areas of polygons, add an “Area” column to the polygon table. Note you must set the projection to a metre projection, e.g. UTM, not geographic degree units, and select your units in the Project Properties > General > Measurements dialog box. You can then populate this field by using the calculation option in the Attribute Table option. Make the layer editable and then use the \$area function to calculate the relevant field area.

Note that the units of area are set in the Project Properties > General > Measurements dialog box. These units can be changed on the fly, but you need to refresh the values in the calculated area column to reflect the new units. The area can also be viewed by selecting the Layer Properties > Display > Field option so that the area can be displayed when you hover over the mouse over the polygon when the Info Tool is activated.

geology_surface_sd5112 :: Features total: 906, filtered: 906, selected: 0			
	CODE	JNCODE	Area
1	Qc	sd5112;Qc	0.37
2	P_kl	sd5112;P_kl	0.04
3	P_kl	sd5112;P_kl	0.08
4	Qs	sd5112;Qs	0.07
	D_kr	sd5112;D_kr	0.03

Areas can also be calculated via the “Calculate Geometry” plugin. Right click on the layer name in the Layers Panel and select “Calculate Geometry”. The Calculate Geometry plugin allows you to select your area units. Perimeters can also be calculated this way. Make sure you do some check areas to ensure your results are correct.

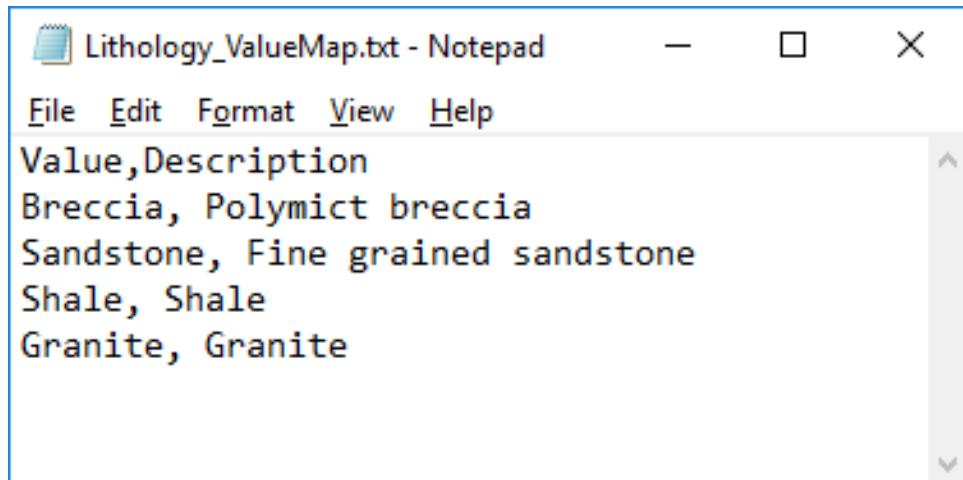


To digitise a polygon, make the layer editable and choose the “Add Feature” polygon icon (4th from the left). Click around the polygon using left mouse clicks and finish the polygon with a right mouse click. Nodes can be shifted and added-deleted using the node icon, as per the line editing options.

### 7.5.1 Creating Drop-Down Lists for Data Entry

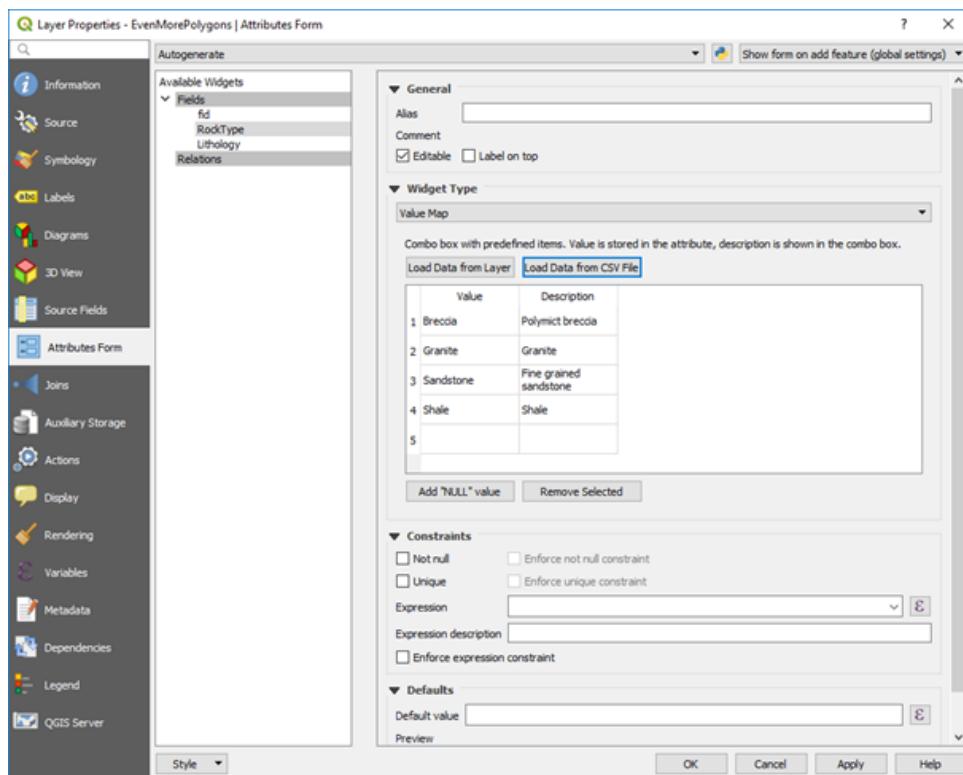
A **drop-down list** can be created in QGIS to allow for the attribution of vector items. The use of a drop-down list prevents typographical errors in data entry and can be used to restrict non-standard item names. You can use data from an existing layer or use a csv file for the source of the drop - down box data.

The example below shows a csv file that has been used to apply attributes to the polygon layer.



```
Lithology_ValueMap.txt - Notepad
File Edit Format View Help
Value,Description
Breccia, Polymict breccia
Sandstone, Fine grained sandstone
Shale, Shale
Granite, Granite
```

In the Layer Properties, select the Attribute Form tab, and change the widget type to “Value Map”.



The Form Value Relation is used to apply multiple nested dropdown boxes for use in pre -set data entry options. This is useful for entering specific rock types, geological codes or formation names.

The following is from North Road Consulting who completed a crowd funding campaign to get this feature into the core component of QGIS.

*“What happens is you have pick lists that can change based on other values. Have a pipe? It can be made out of W, X, Y, and Z. Is it a Water Pipe? It can only be made of X and Z. Wastewater Pipes can only be made of W and Y.*

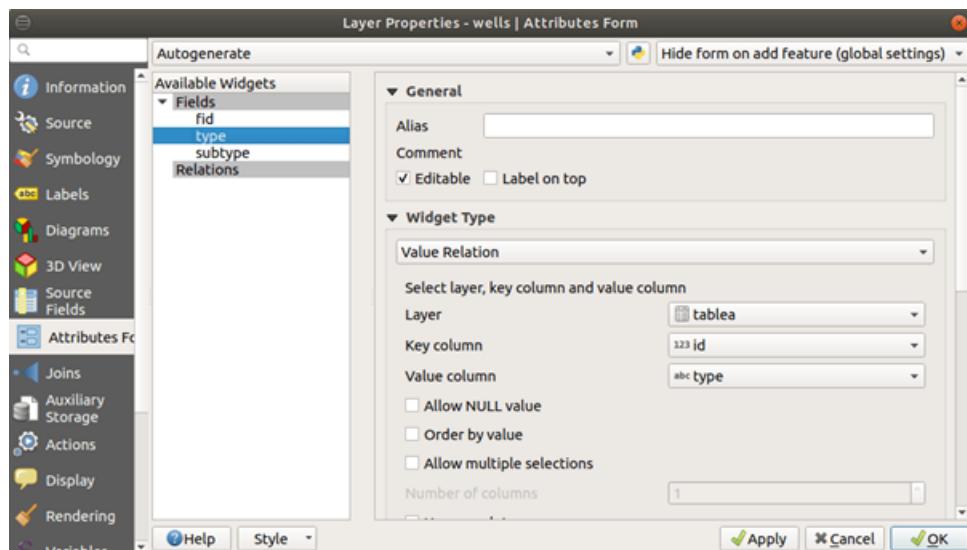
Here is my walk through. I have a point layer and that point layer has a type and a subtype. I stored this all in a GeoPackage by the way. The type drives the subtype. You select A and you can only have red or blue. Maybe B is green and white. There are two tables to help with this process tableA is 2 fields: a primary key and a value. TableB has three fields: a primary key, a value, and a foreign key that relates back to Table A. From that you can see Type A can only have a value of Red and Blue. Type D can only be Black and Gray.

tablea :: Features Total: 4...	
1	1 A
2	2 B
3	3 C
4	4 D

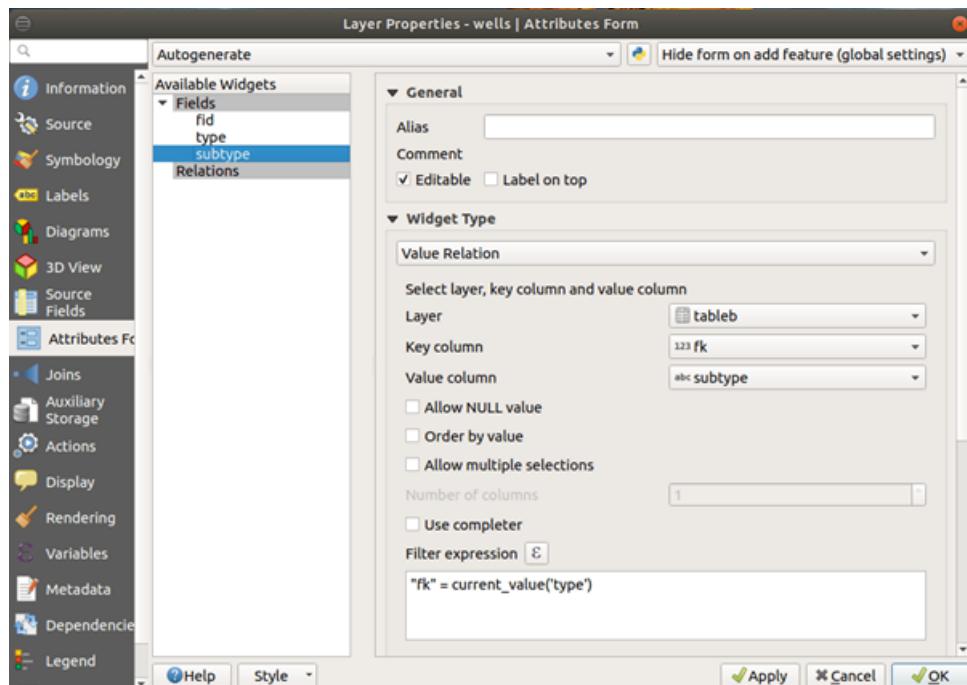
  

tableb :: Features Total: 8, Filtered: 8, Sele...		
1	1 red	1
2	2 blue	1
3	3 yellow	2
4	4 green	2
5	5 white	3
6	6 pink	3
7	7 black	4
8	8 gray	4

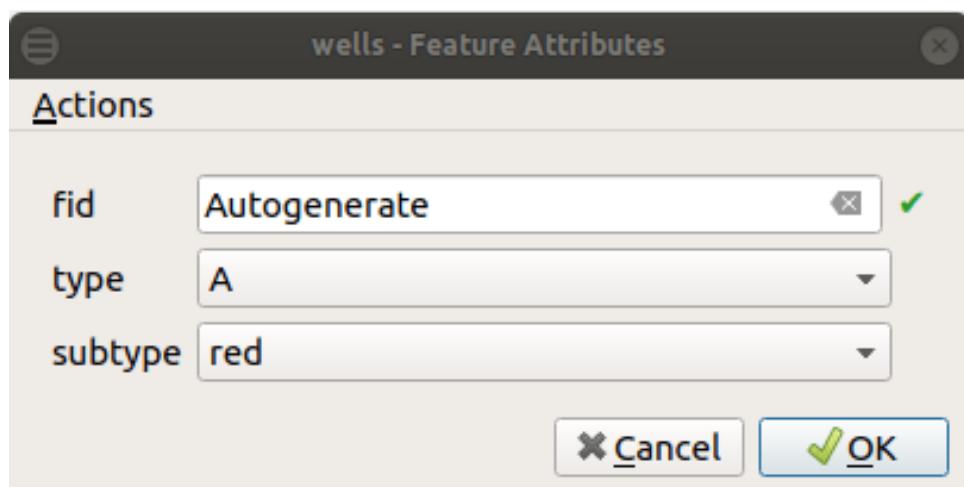
The point layer has two attributes of concern: type and subtype. Type will be A,B,C, or D. Subtype will be a range of colours that Match the Type picked. If you right click the layer and select attribute forms you can assign a form for data entry. In this case for type the key column is the primary key and the value is the type. Note the Widget type is Value Relation!



Lets looks at the subtype field. The key column is the Foreign Key (the part that relates it back to table A). The value column is the subtype. The magic is this - if you look at the filter expression: "fk" = current\_value('type'). See below.



The foreign key equals the value of the type widget. When you add a point, you'll see the type drives the subtype.



In summary, if you select type A, you will only get an option to select colours red and blue."

Value Maps and Form Value Relations are useful tools for adding data. For geological data, you might have a list of rock classes (igneous, sedimentary, etc) and a list of lithologies (basalt, granite, sandstone, etc) for polygon data, or observation type (bedding, joint, vein, etc) for point data.

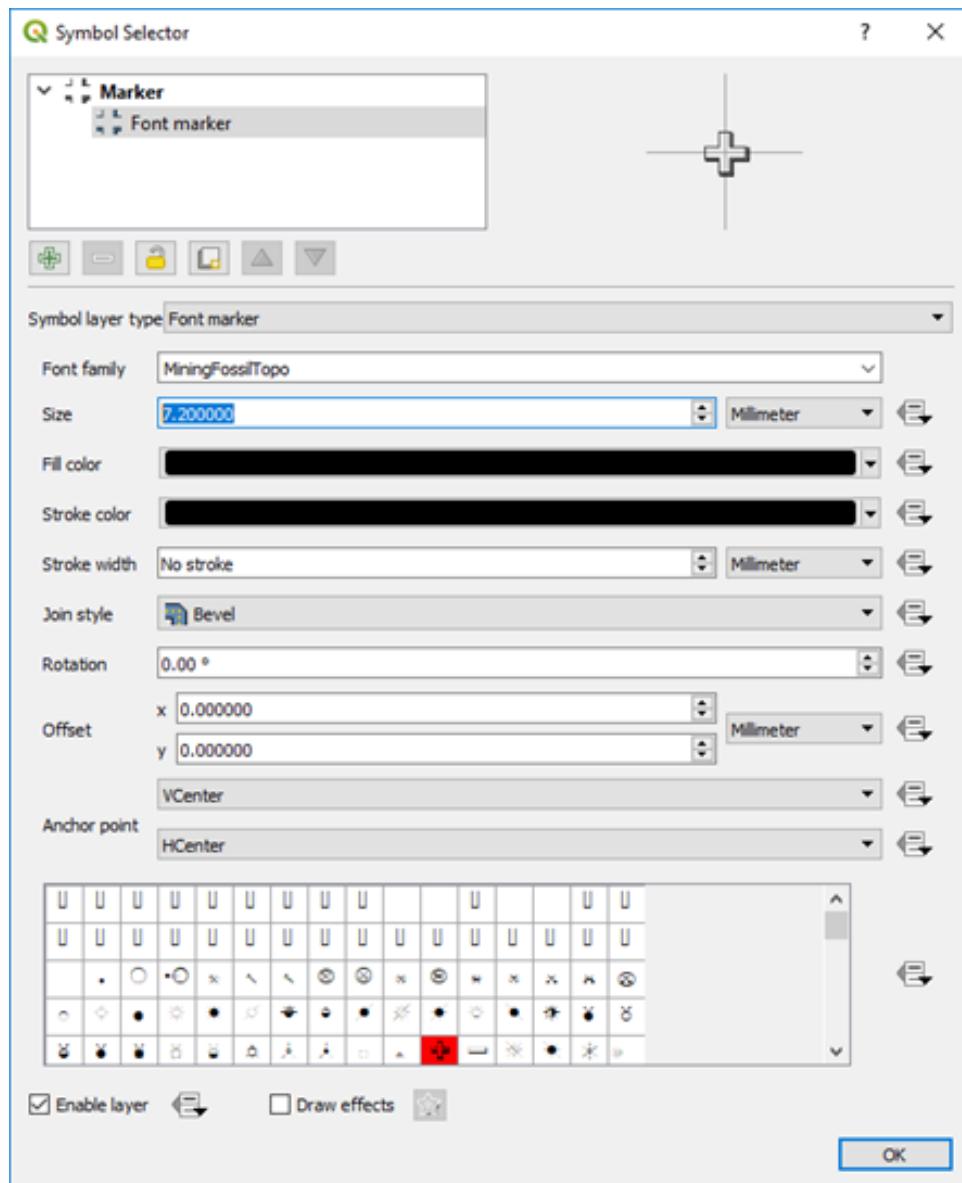
## 7.6 Geological Symbols and Geological Patterns

Geological symbols can be either specific geological fonts (True Type Fonts) or SVG (scalable vector graphic) symbols. Geological symbols can be [downloaded from the internet for free use in QGIS](#). On Windows systems, geological symbol fonts need to be installed by right-clicking on the font file name and selecting Install. Note that some fonts, particularly the ESRI fonts, are proprietary and not free use.

### 7.6.1 Geological Fonts

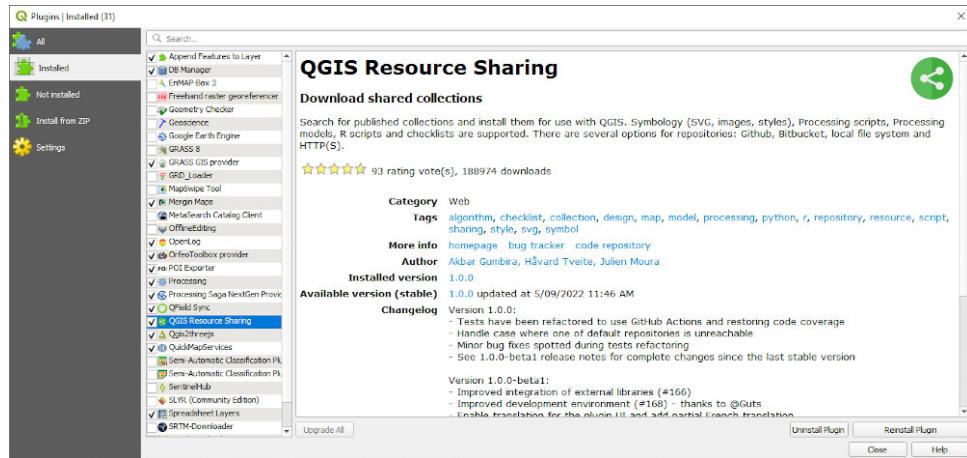
Four font sets are available from Geoscience Australia and include ESRI Geology AGSO 1 to 3 (esri\_500.ttf), ESRIGA\_0.ttf and ESRIGA\_4.ttf), GeoscienceMining (GEOSM\_.ttf) and MiningFossilTopo (MINIFT\_.ttf). Other geological and cartographic fonts may also be available depending upon what other software you may have installed (previous MapInfo or ESRI fonts may already be installed on your system and could also be used). Fonts installed on Windows can be accessed via the Windows run box and typing “fonts”.

Geological font symbols are accessed via the Layer properties > Style tab and choose the symbol layer type as “font”. All the fonts installed on your computer will be accessible and you will need to search through the installed fonts to find the relevant font file and then the relevant font symbol.

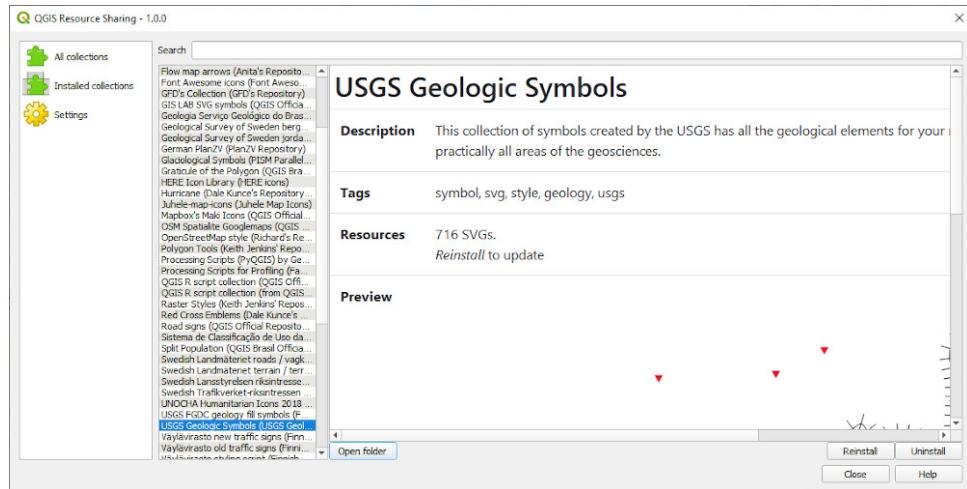


## 7.6.2 SVG Symbols and Patterns

The USGS symbols and patterns can be downloaded from various locations on the internet but the easiest way is via the QGIS Resource Repository plug-in.

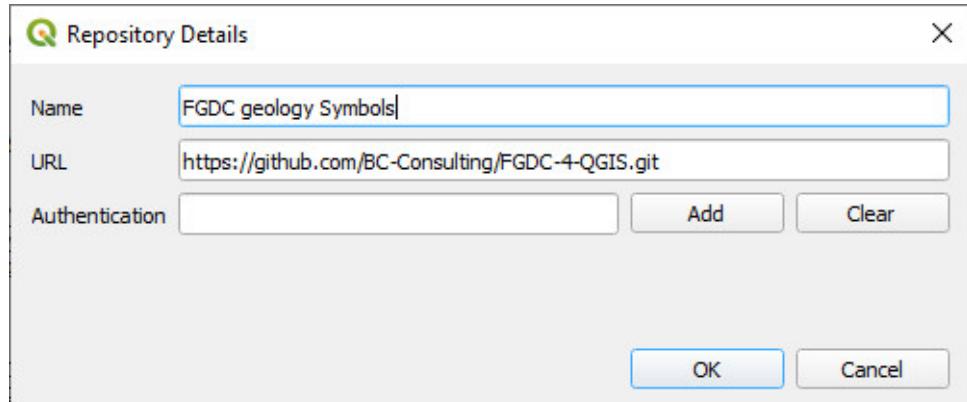


Enable the plug-in and then search for the USGS symbols under the ALL tab.



Install the symbols and these will then be accessible via the symbol selector > SVG > SVG Browser > Collections.

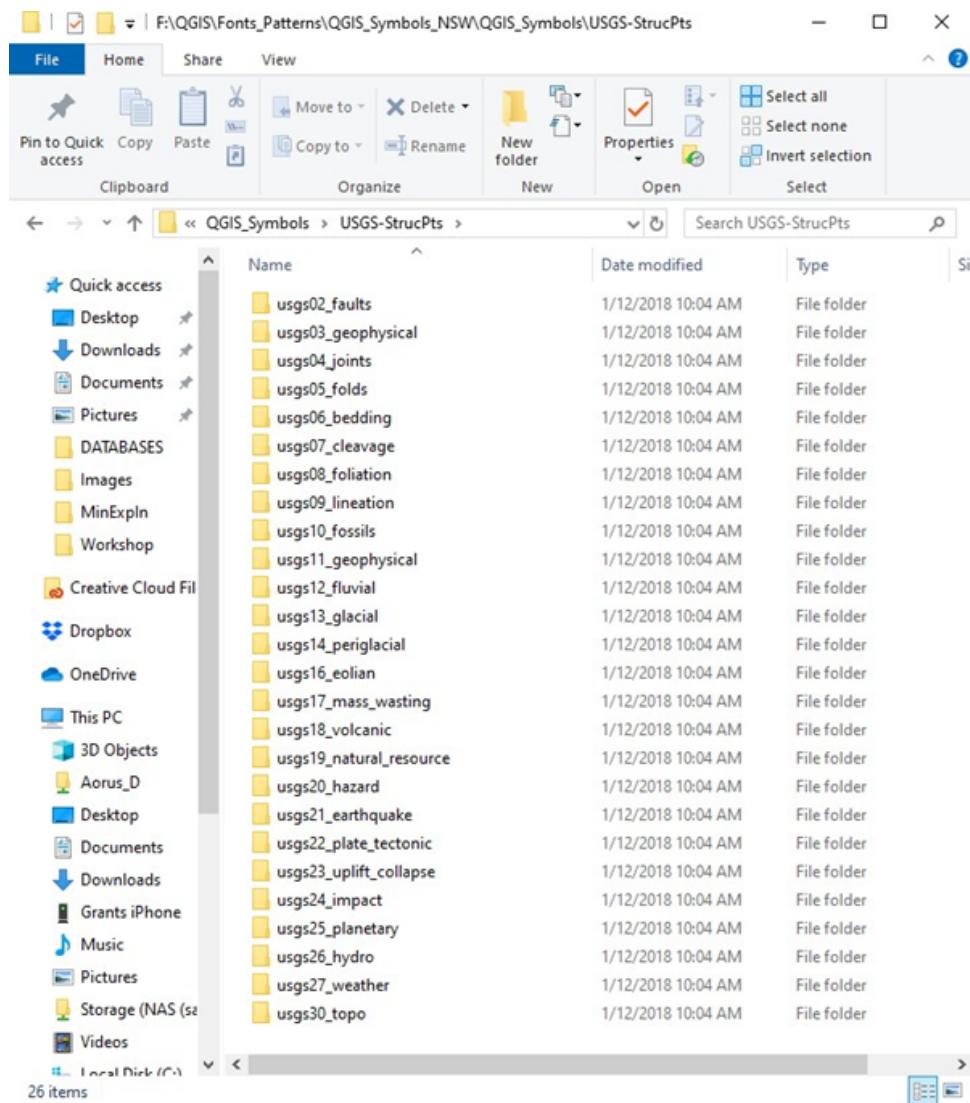
To install the USGS pattern fills, we need to add a new repository to the Resource Sharing plug-in.



Install the pattern fills and these will then be accessible via the symbol selector > SVG > SVG Browser > Collections.

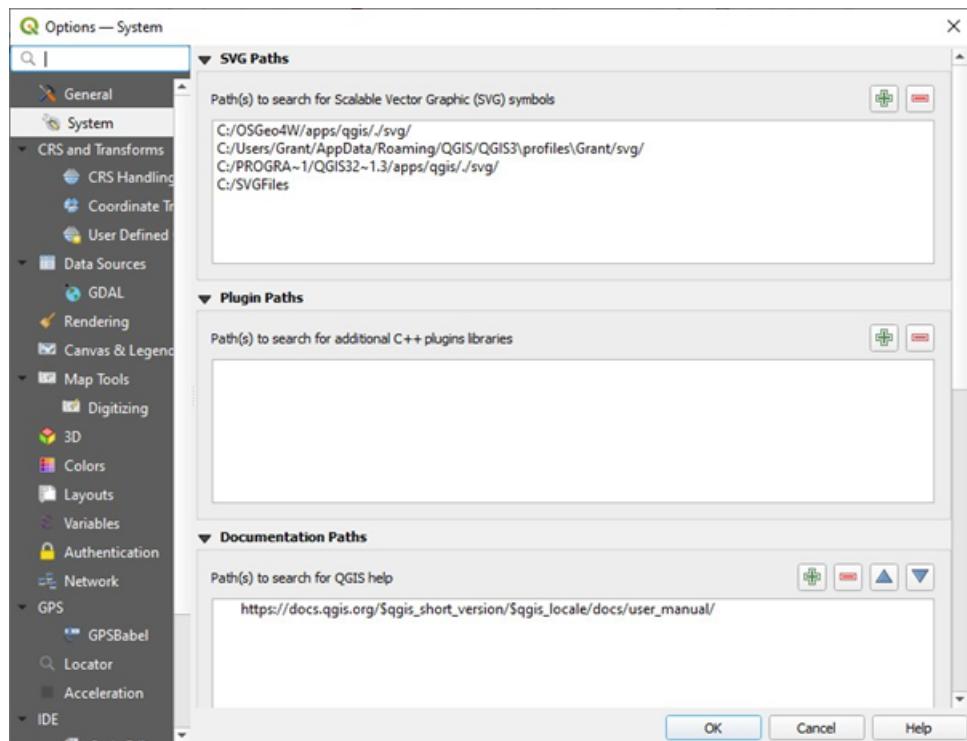
A selection of SVG geological pattern files shown in the appendix were initially sourced from Stefan Revets'

page and modified to allow the overprint pattern to be coloured. Also see this page <https://github.com/afrigeri/geologic-symbols>. An alternative location for geological SVG patterns is [here](#). The NSW geological survey also supply symbols for their state wide geological maps and are based on the USGS FGDC symbols and the symbols are supplied in folders based on the FGDC documentation.

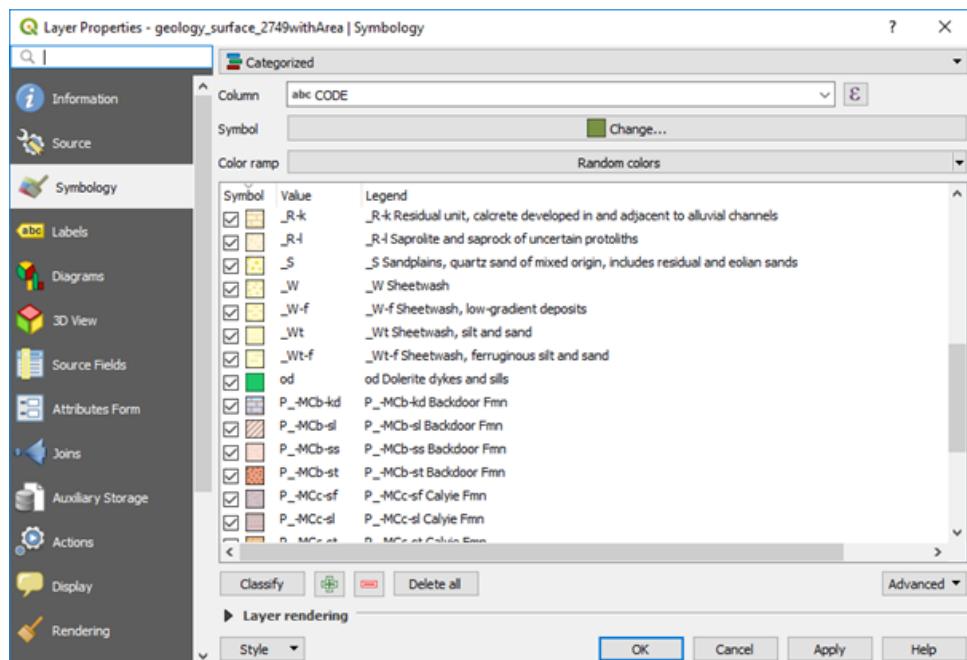


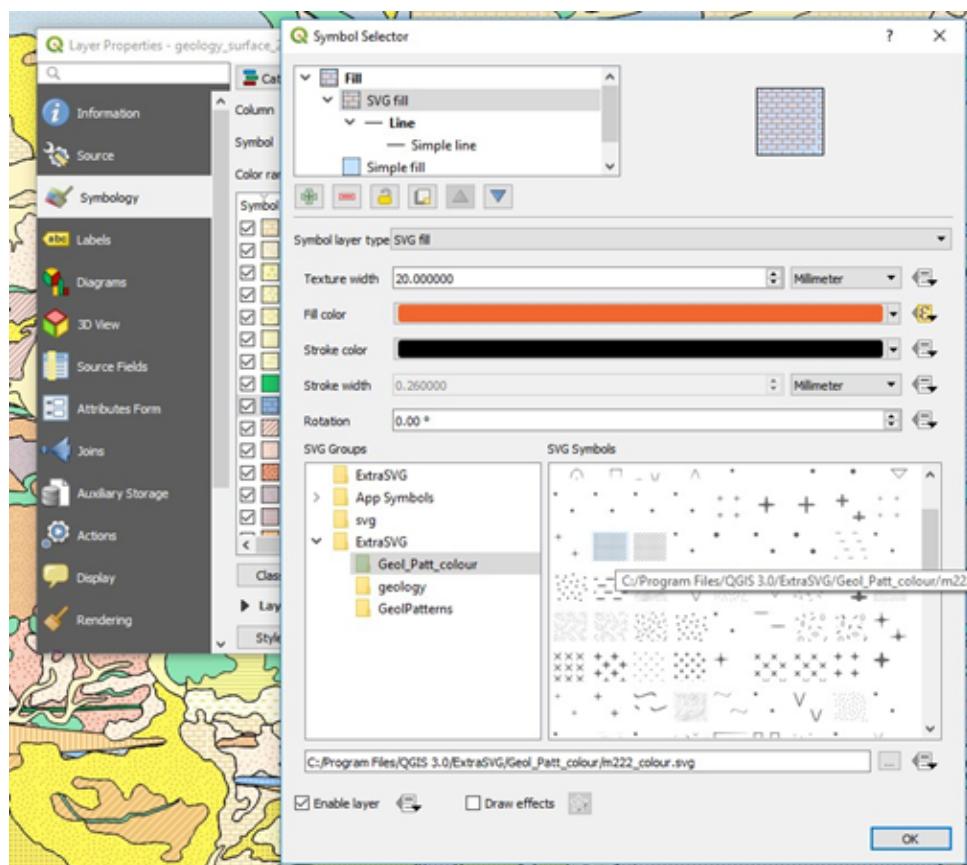
SVG files can be stored anywhere but the default location for the standalone install option is the Program folder, for example C:\Program Files\QGIS 3.26\apps\qgis\svg. Note that if you install QGIS via the OS4Geo option, the SVG files will be located in the “C:\OSGeo4W64\apps\qgis\svg” for the long-term release version, or the “C:\OSGeo4W64\apps\qgis-dev\svg” folder for the development version. It is recommended that this folder is used for the additional geological symbol and patterns so QGIS will find these by default and you will not require to specify an additional SVG directory location. If you upgrade your version of QGIS, you may need to copy your extra SVG files back into this folder.

Alternatively, save the SVG folder to another separate folder and point QGIS to that folder using the Settings > Options > System tab.

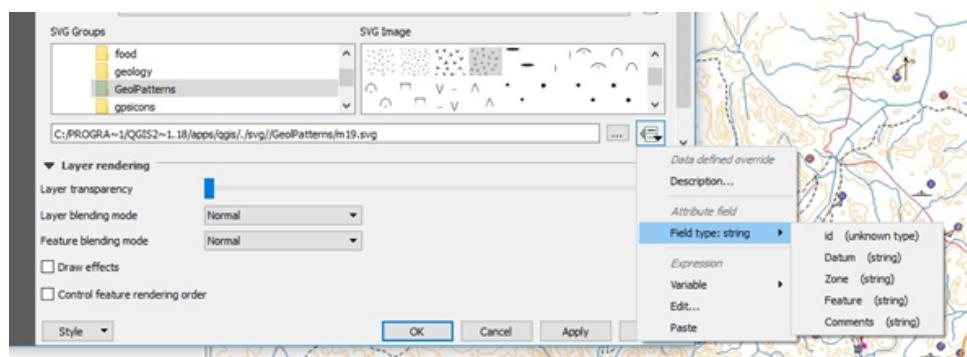


To use the geological patterns, for example, you would categorise the layer based on a geological code and then allocate each code a specific pattern fill, and background polygon layer. The image below shows the result of “Categorising” the geology and colouring each geological code type.

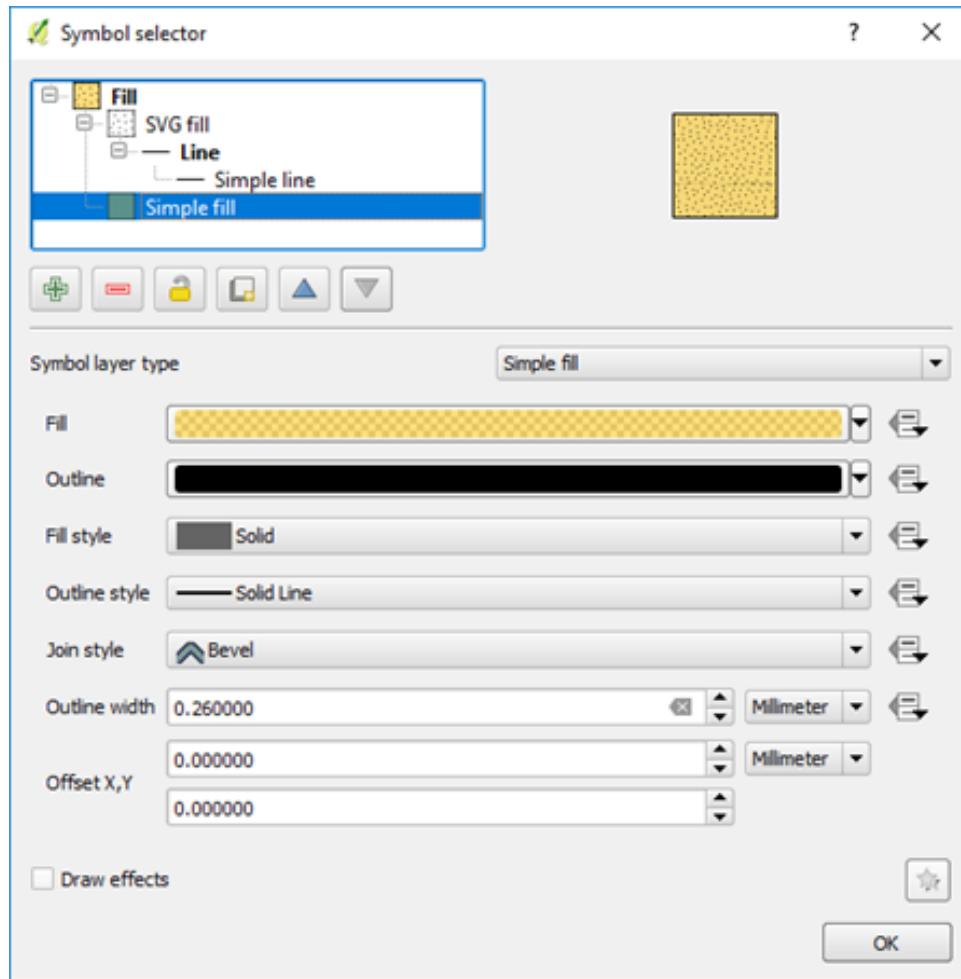




Note that you have options for size and rotation of the patterns or symbols. The SVG symbols and patterns have discrete file names which can be used to automatically assign symbols and patterns in the “Data Driven Override” of the layer properties file window.

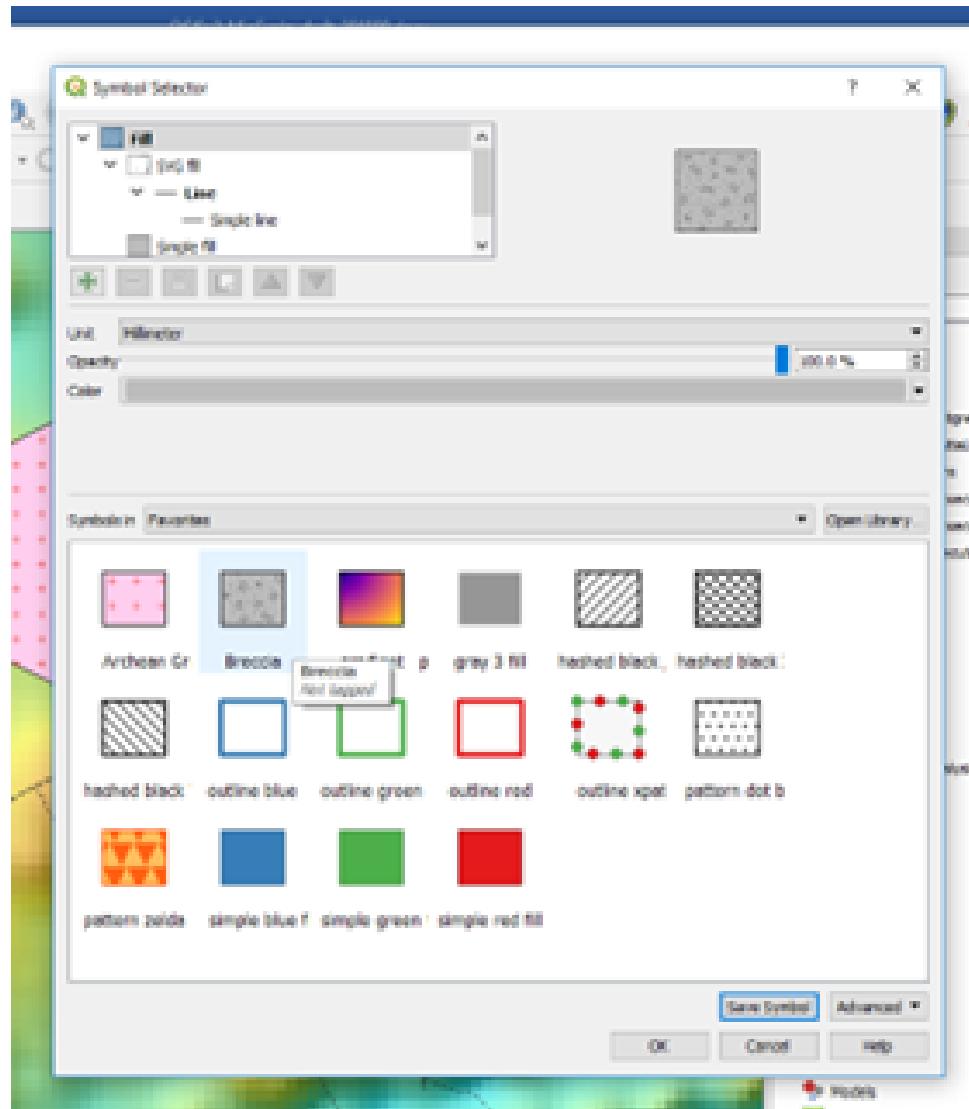


Coloured backgrounds can be added to the polygon fill by adding another layer in the Symbol Selector dialog box. Add a new symbol layer by using the green plus symbol and move it to the bottom using the down arrow key below the display box.

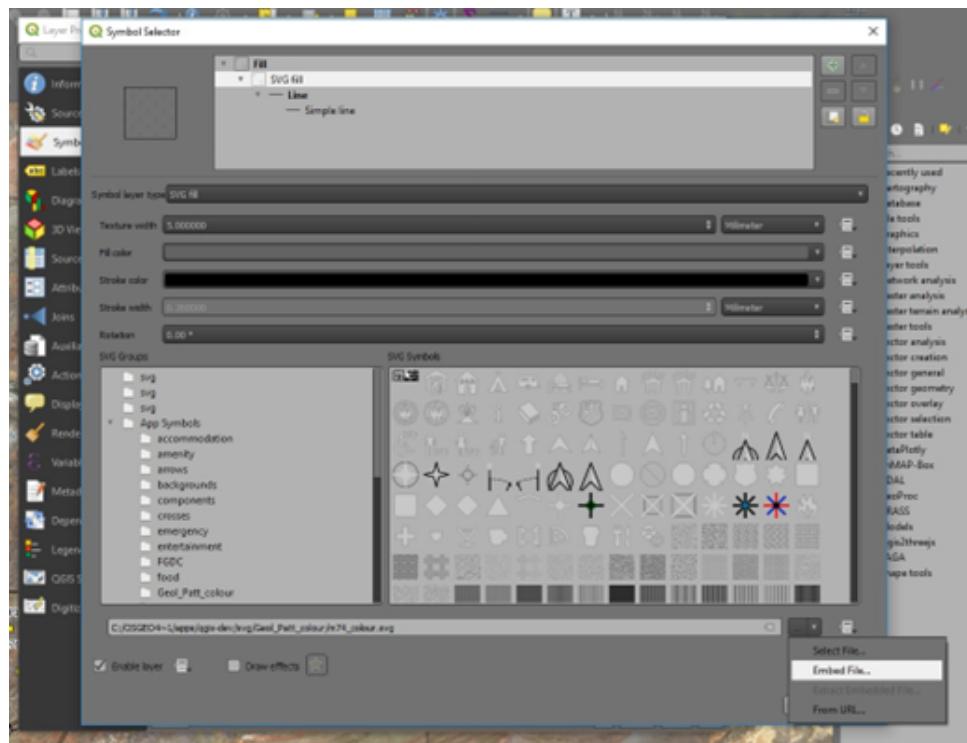


For assistance in selecting colours, go to the “Color Brewer” website where there is a vast array of colours and their specifications available. Colour specifications can be specified in QGIS via their hex, RGB or CMYK number.

If you have favourite fill styles, these can be saved as “Favourites” which are then quickly accessible via the Symbol Selector dialog box.



The SVG fills can also be “embedded” into the file via the “Advanced” options and this allows the files to be used by other users that may not have the relevant SVG files installed on their machines.

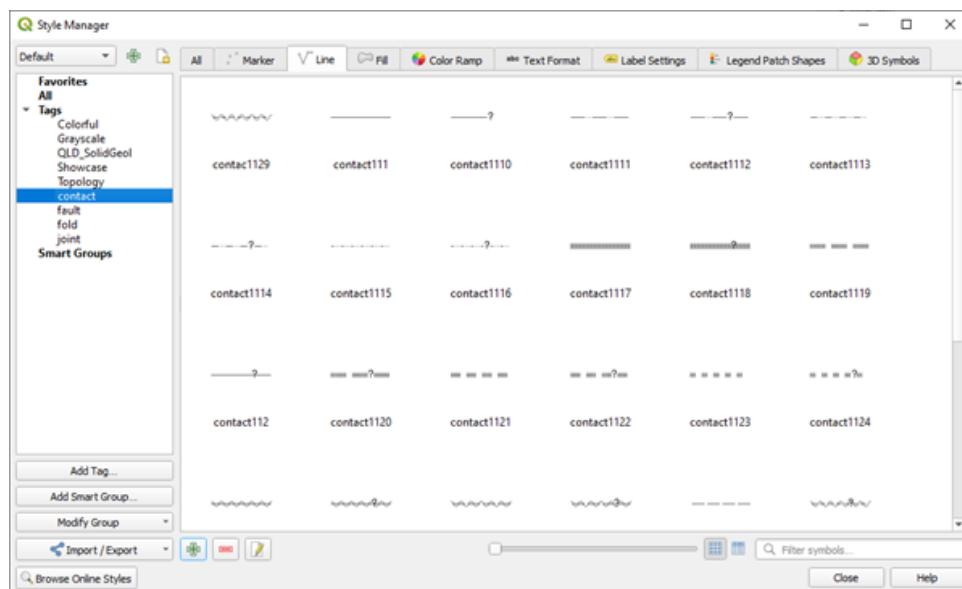


## 7.7 Geological Line Styles

Linear geological features can be displayed by manually editing the line style in the Layer Properties > Style tab, or by using line styles set up in the top menu Settings > Style Manager window. Full details of how to construct various line styles can be found in a comprehensive document put out by the USGS and can be found [here](#).

Style (\*.xml) and symbol (svg) files can be found here at [Stefan Revets' site](#) and in the NSW QGIS Symbols in the “QGIS\_SymbolsFGDC\_GeologySymbolsgvg” folder. Line styles include geological contacts, faults, folds, and joints and are based on the FGDC symbology.

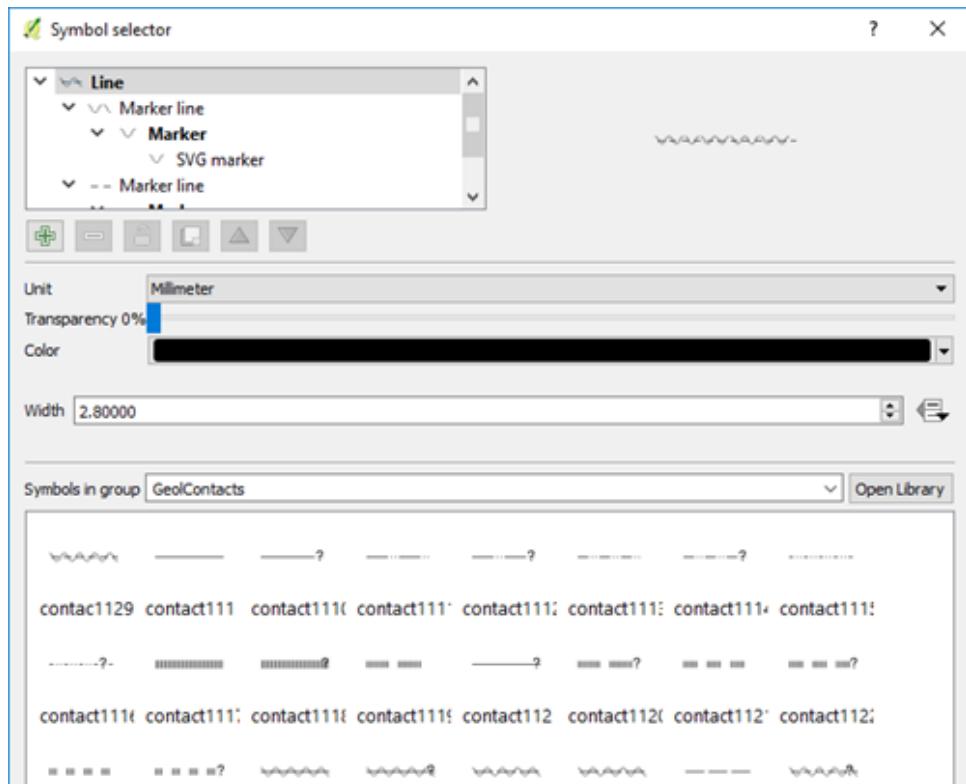
On the main menu, go to Settings > Style Manager and select the Import option in the small box down on the lower left-hand side of the dialog box (looks like two blue lines with dots). Save each group with a name (“tag”) so that you can easily identify which line style group you want to display.



Navigate to where your line styles are stored. Import each one (e.g., contact, fold, fault and joint). Remember to add a “tag” so they can be easily selected in the Style Manager.

In the Symbol Selector dialog, select the “Symbols in group” drop-down box, select “contacts” (or whatever you called this line style group). Select the line style you want and hit OK. This method can be used to modify all the other line styles. To save these line styles remember to save the Style as default in the main Style tab window (under Style > Save as Default).

If you have multiple line styles, make sure you have a column in your table to allow the line types to be “Categorised” so that specific line types can be allocated to different line types.



Any of these line styles can be edited manually by selecting the layer in the top window.

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**Note:** You can change the line direction, e.g. fault ticks on other side, by using the “Reverse Line Direction” in the “Advanced Digitising Toolbar”.

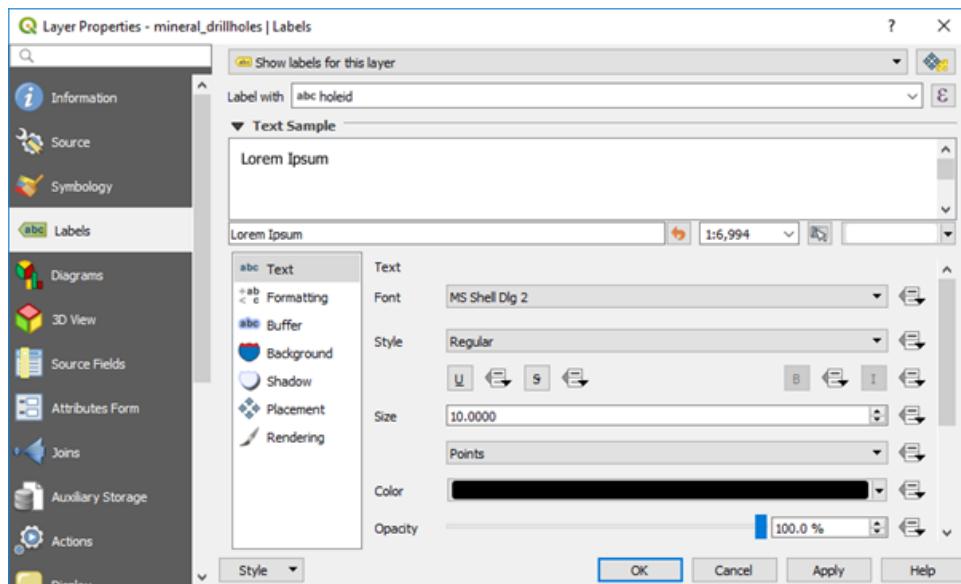
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## 7.8 Labelling Features

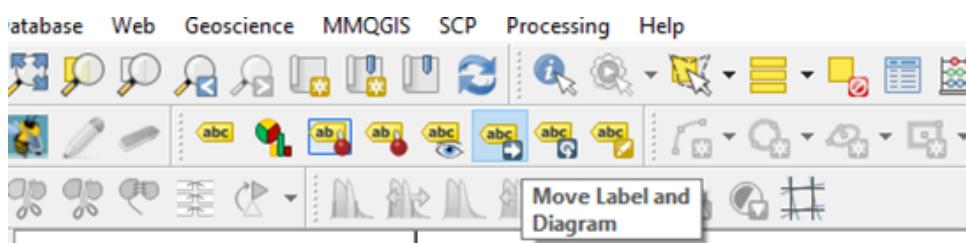
Features can be labelled via the Labels tab in the Layer Properties window for each layer. There are many ways to place labels and format them. I will give some examples typically used in geological applications below but there are many other options which you are encouraged to explore (see QGIS User Guide - section 12.3.3 and Graser and Peterson 2016 - Part 2). Note that you can have the labelling panel open and docked by pressing F7, and when you make changes to the labels these are immediately displayed in the map widow. This method removes the requirement to click OK/apply to see changes.

### 7.8.1 Labelling points

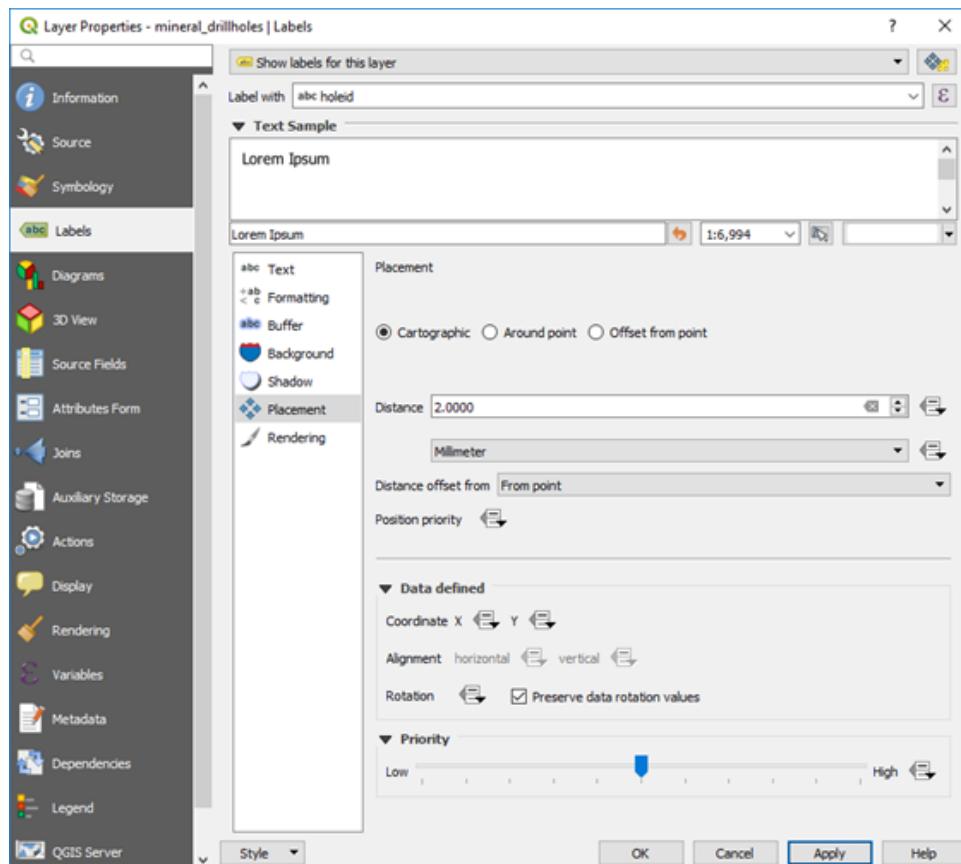
The Labels tab shows a variety of labelling options such as font type and size, whether you want a halo around the label (buffer) which is useful when the labels are over a coloured background. The Formatting section allows you to specify multi-line labels and word wrap options. The Placement options allow you to test different ways to display your labels.



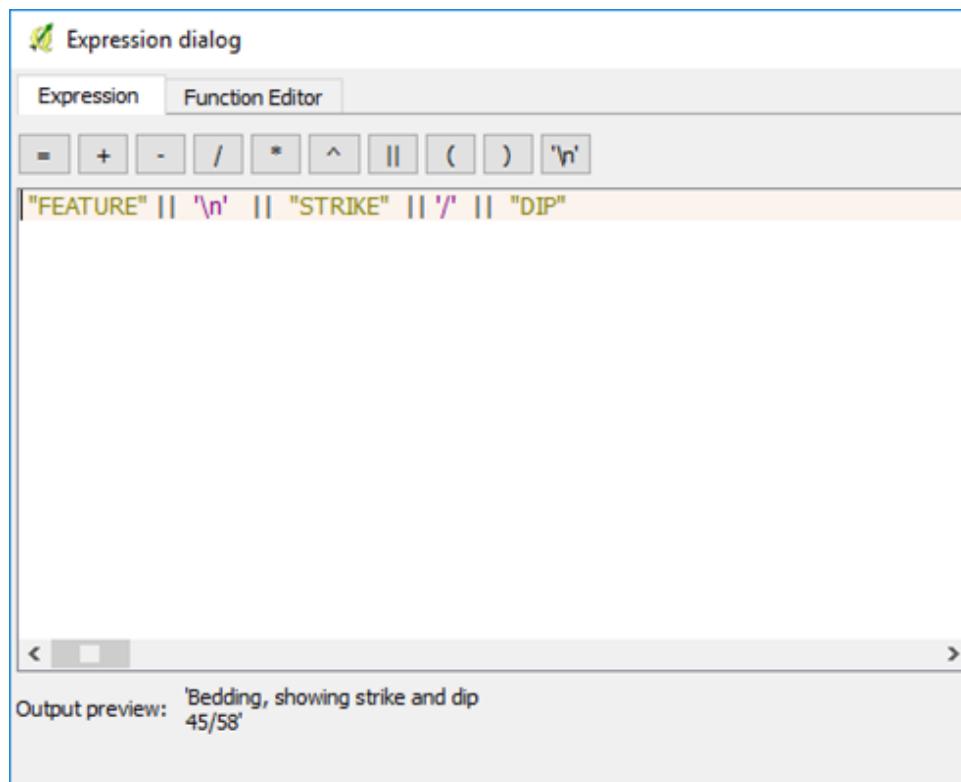
Note that to manually move individual labels, use the “Move Label or Diagram” option in the labelling toolbar.

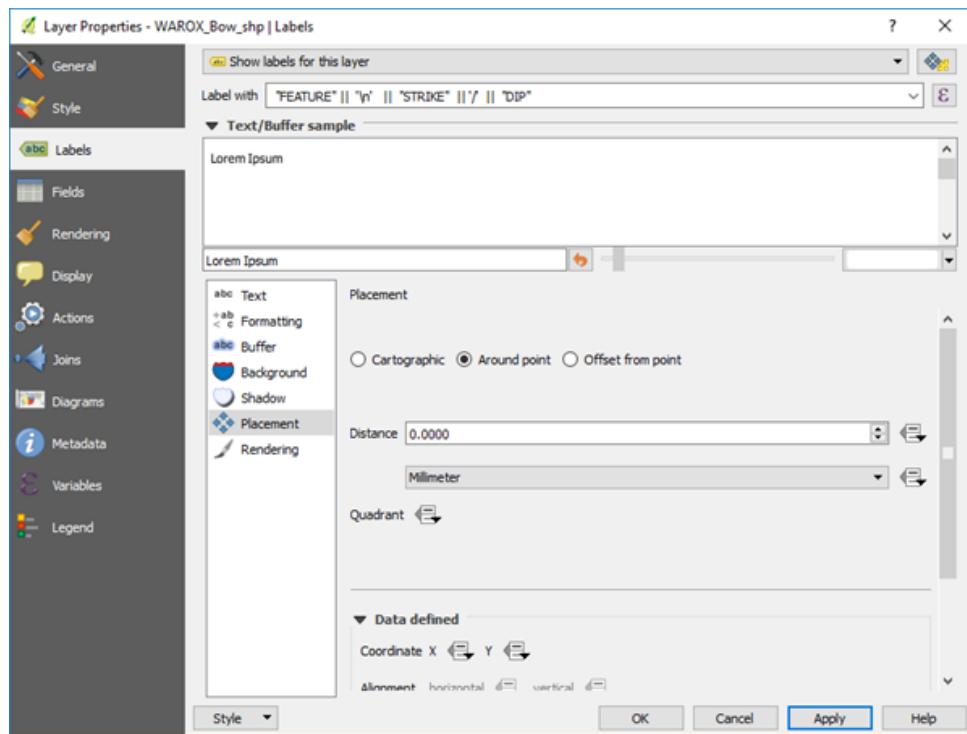


There are three placement options, and it is suggested to test these options for each application. The “Cartographic” option (points only) will move labels to suit the display. If you need a “halo” around the labels, use the Buffer option. To rotate all the text labels, use the Labels > Placement > Offset from point > Rotation option. This option is useful for labelling drill holes along grid lines.

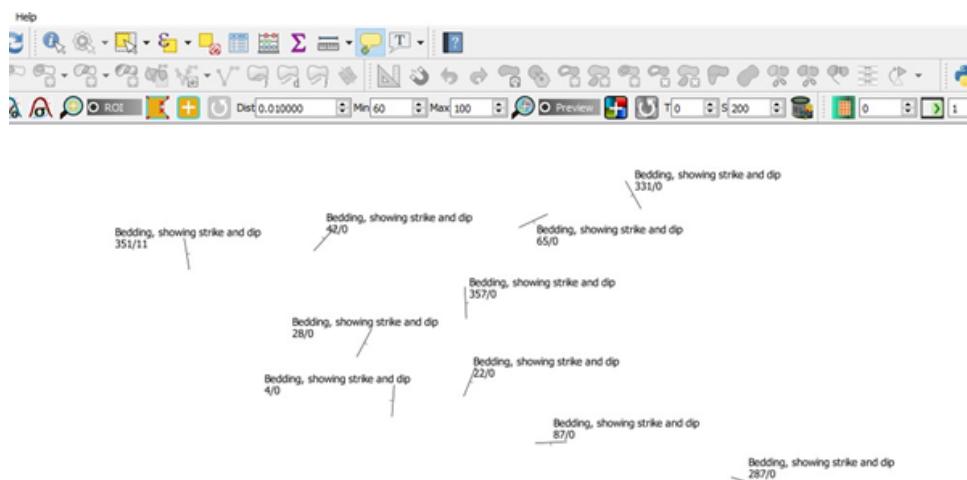


Multi-attribute labels can be created using the expression editor. Note the “Output Preview” in the lower left of the dialog box which shows how the labelling will appear.

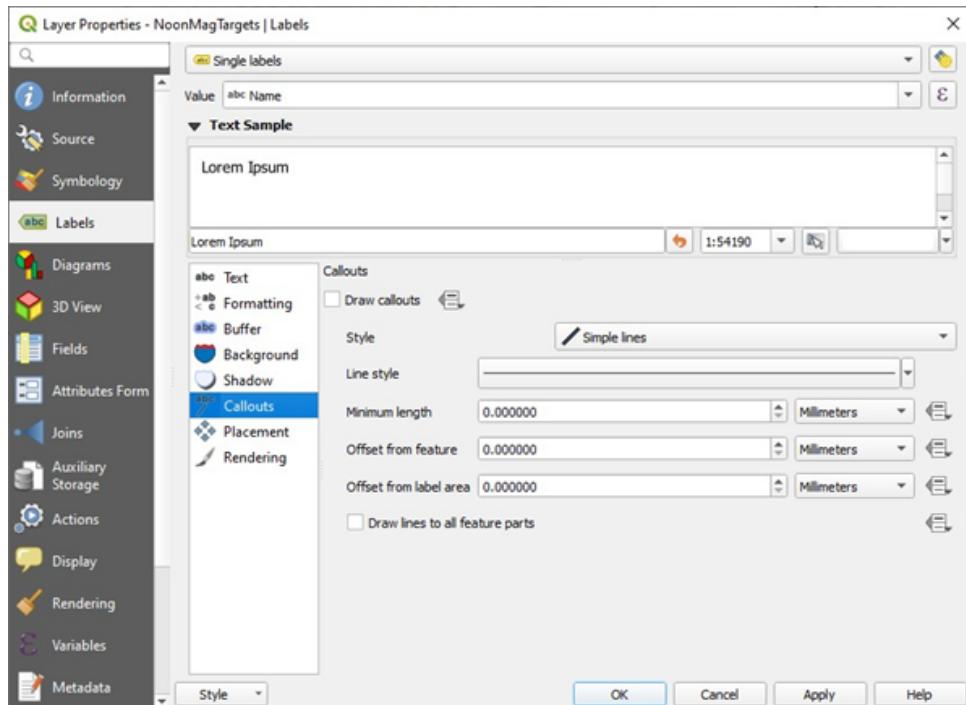




An example is shown below displaying the structure type with strike and dip.

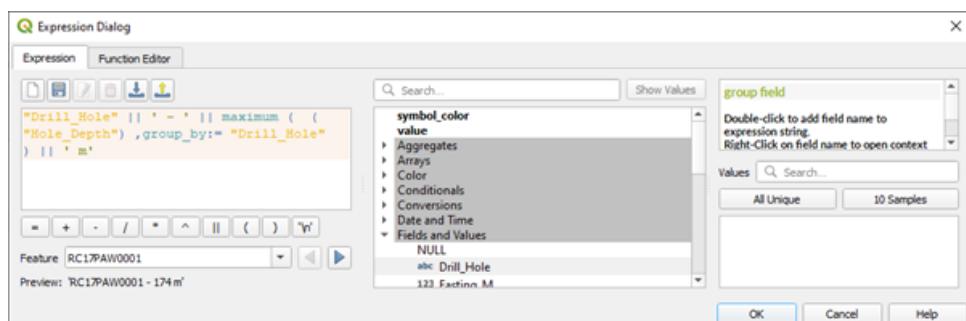


In the Layer Properties > Label there is an option to add “call-outs” where lines can be automatically created to join a point to a label.



Labelling drill holes with collar names and depths of holes can be achieved using the expression editor in the labelling tab. Note to check the Preview to ensure your syntax is correct.

`"Drill_Hole" || ' - ' || maximum ( ("Hole_Depth") ,group_by:= "Drill_Hole" ) || ' m'`

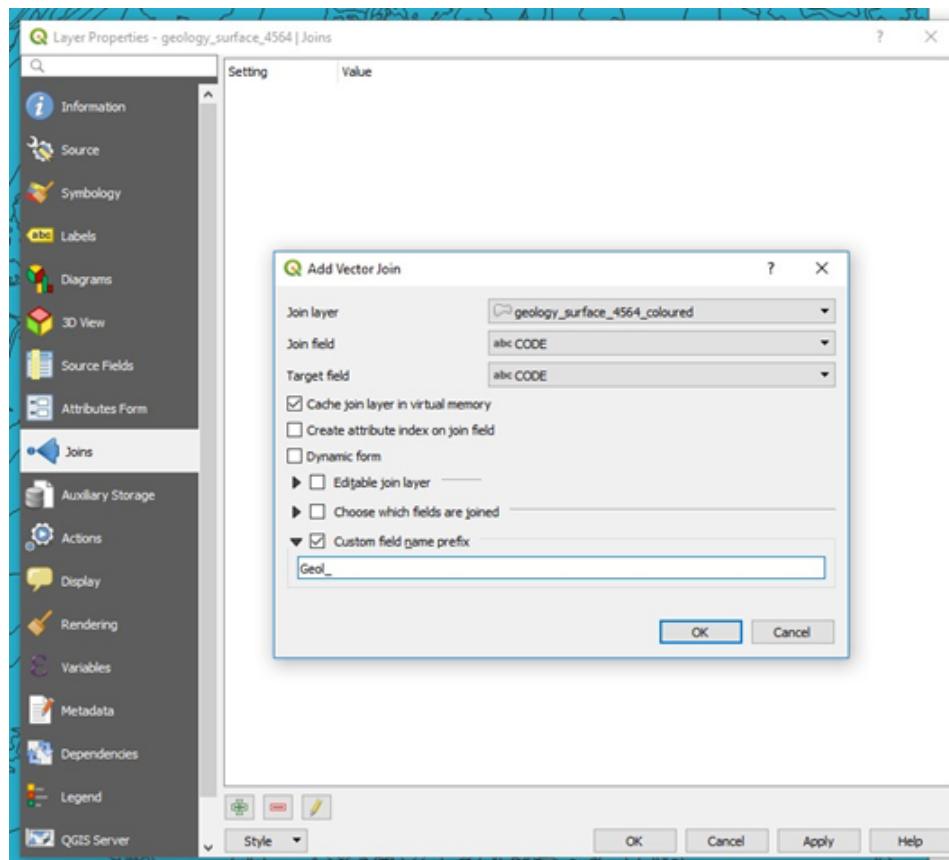


## 7.9 Joining Spatial and Non-Spatial Data

Joins are done via the Layer Properties dialog box. Open both the spatial file (i.e. the layer that is spatially located) and the non-spatial file (without spatial reference). The non-spatial file can be opened by the spreadsheet or text file import and with “No geometry” selected. The non-spatial layer will appear as a spreadsheet icon in the Layer properties panel. Select the spatial layer in the Layers panel you wish to join, open its Layer Properties > Join tab, press the green plus to add a new join, select the join fields (which must have data in common in both layers to allow it to join).

The example below (Bow 100k map sheet) shows the join of the geological polygons with the geological descriptions (from an Excel file) for each of the geological codes for the polygons.

Individual fields can be selected for the join using the “Choose which fields are joined”. Select the “Custom field name prefix” and change it to a short abbreviation, remembering that shapefiles can only have a maximum field name size of 10 characters and this may cause problems later as field names may have been truncated.



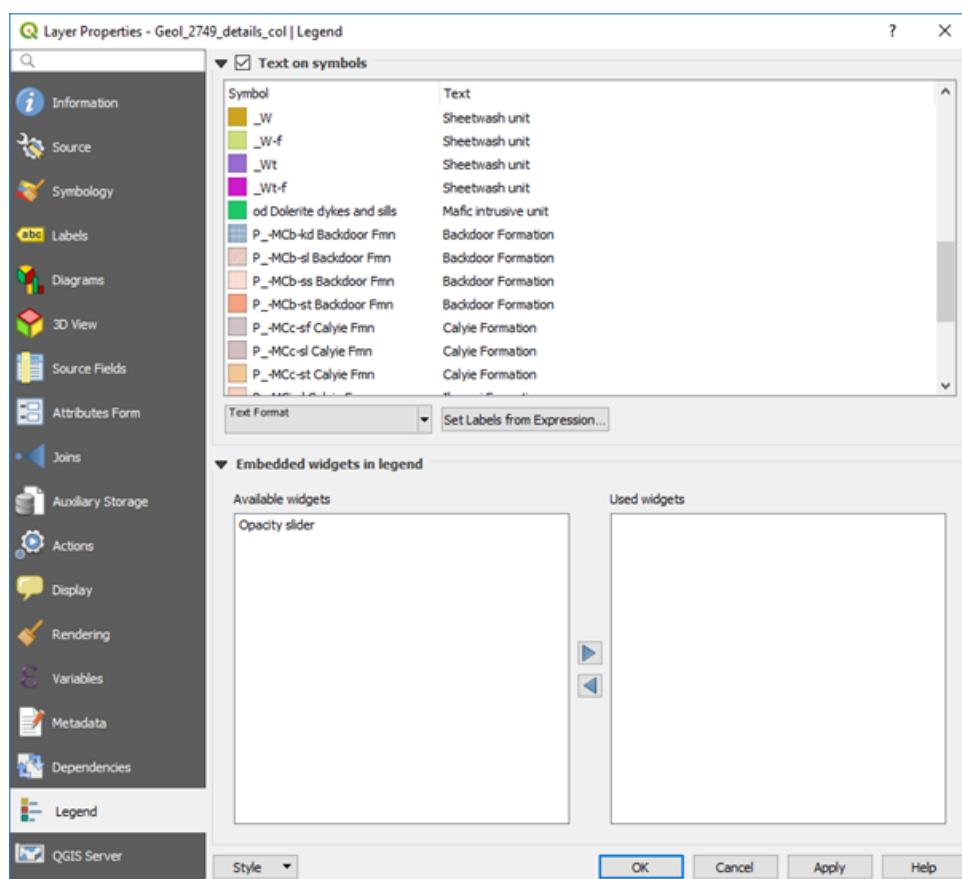
After clicking “Apply”, examine the join results by opening the layer attribute table and ensuring the join has been successful.

	AREA	PERIMETER	GEOOBS_	GEOOBS_ID	CODE	JNCODE	Geo_JNCODE	Geo_NARRATIVE	Geo_COMP
1	0.00002	0.01937	2	108	Csa	4564:Csa	4564:Csa	Alluvium and colluvium - partly con...	
2	0.00026	0.08337	3	107	PLgne	4564:PLgne	4564:PLgne	biotite monzogranite	Lamboo Comp
3	0.00001	0.01472	4	106	PLCI	4564:PLCI	4564:PLCI	LISSADELL FORMATION: fine- to c...	
4	0.00058	0.26652	5	100	Czs	4564:Czs	4564:Czs	Alluvium and colluvium - partly con...	
5	0.00001	0.01444	6	89	DCg	4564:DCg	4564:DCg	GALLOPING CREEK FORMATION: f...	
6	0.00024	0.09028	7	94	Czn	4564:Czn	4564:Czn	Unconsolidated and partly consolidated sandplain deposits	
7	0.00012	0.07798	8	103	DCg	4564:DCg	4564:DCg	GALLOPING CREEK FORMATION: f...	
8	0.00009	0.04495	9	93	Csa	4564:Csa	4564:Csa	Alluvium and colluvium - partly con...	
9	0.00222	0.64653	10	1035	DCg	4564:DCg	4564:DCg	GALLOPING CREEK FORMATION: f...	
10	0.00000	0.00855	11	101	Czs	4564:Czs	4564:Czs	Alluvium and colluvium - partly con...	
11	0.00000	0.00542	12	102	Csa	4564:Csa	4564:Csa	Alluvium and colluvium - partly con...	
12	0.00122	0.24883	13	88	PLCI	4564:PLCI	4564:PLCI	LISSADELL FORMATION: fine- to c...	
13	0.00123	0.25990	14	82	Ea	4564:Ea	4564:Ea	ANTRIM PLATEAU VOLCANICS: m...	

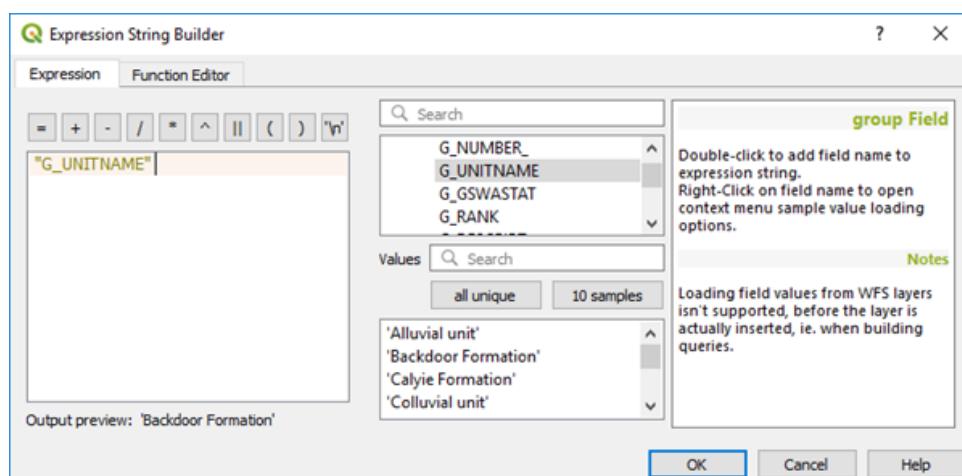
To make this a permanent join, use the “Save As” option by right-clicking on the layer name in the layers panel, and saving the file as a new shapefile layer. If you do not save this joined file, the join will not be permanent, as it is a virtual join only. You may also need to copy the polygon styles from the original shape file to the new spatial file. To do this, right click on the layer name, go to Styles > copy styles > all style categories, then right click on the layer where you want to apply these styles, and paste > paste styles > all style categories. Remember to use the layer properties > Style tab and “save as default” to create a qml file that will automatically apply these styles when the file is re-opened.

## 7.10 Geological Legends

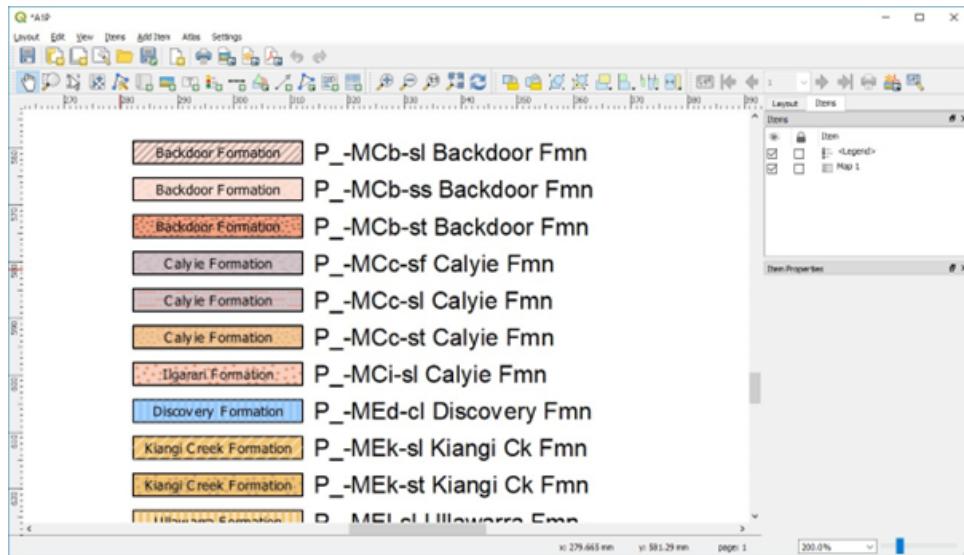
Geological legends in QGIS can be created but the program really needs a plugin to create a geology specific style of legend. Geologists use QGIS very differently to the majority of QGIS users and this would need to be pushed by the geoscience user community. Detailed geological information, e.g., formation names, can be imported into the legend using the Legend tab in the Layer Properties > Legend tab. Note that you may have to join the geological information to the geological polygons, as in the case of GSWA geological data, before you create a more detailed legend.



In the window above, the label text has been selected using the “Set Labels from Expression” which then opens the expression builder window (below).



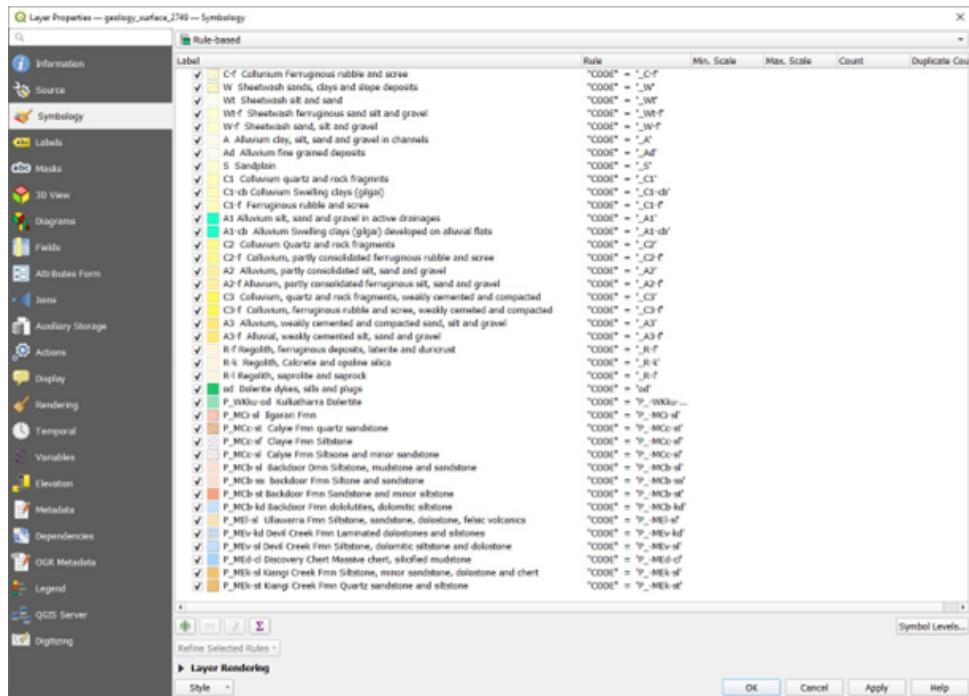
The legend will be displayed in the print layout window as shown below.

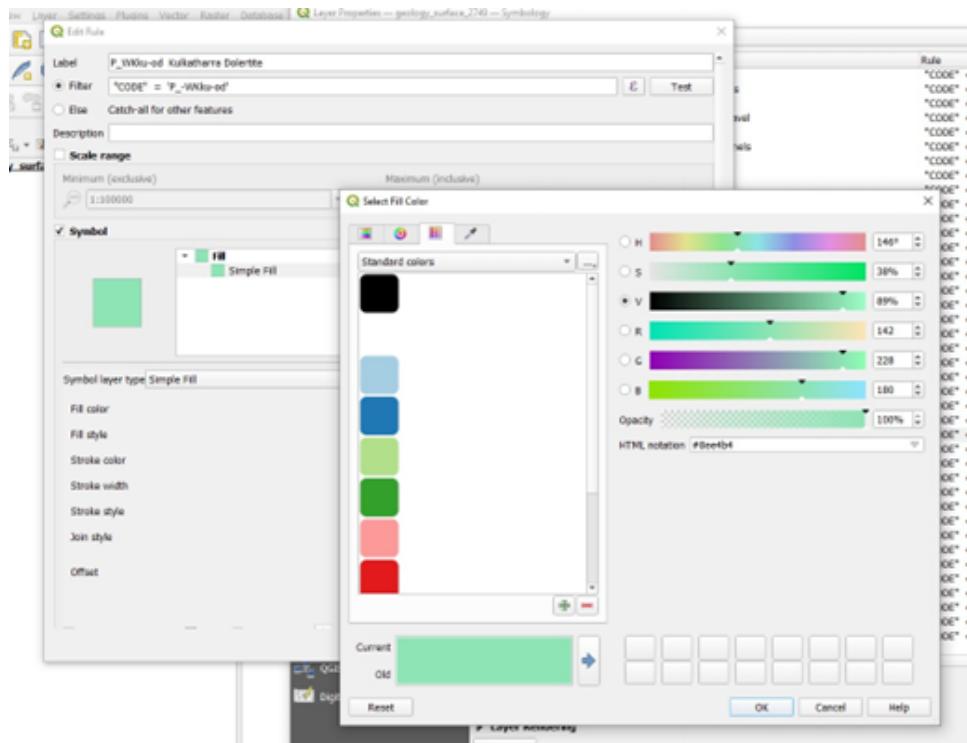


Work is in progress to automatically assign geological patterns and descriptions from the GSWA polygon colouring information and pattern fills with the vector data for their digital maps.

### 7.10.1 Adding user defined polygon colours

If the geological polygon layer is imported from ESRI or MapInfo, the styling information is lost. Some suppliers of this data create qml or qlr files to accompany the shp files to allow custom colouring. To apply custom colours, it is necessary to do a categorical style on the polygon layer based on geological code or name, and then use the rule-based renderer to edit the colour information and polygon name for each geological unit.

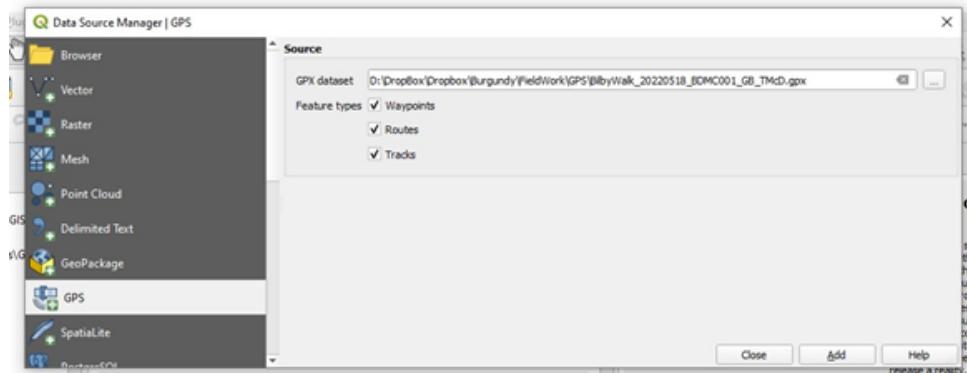




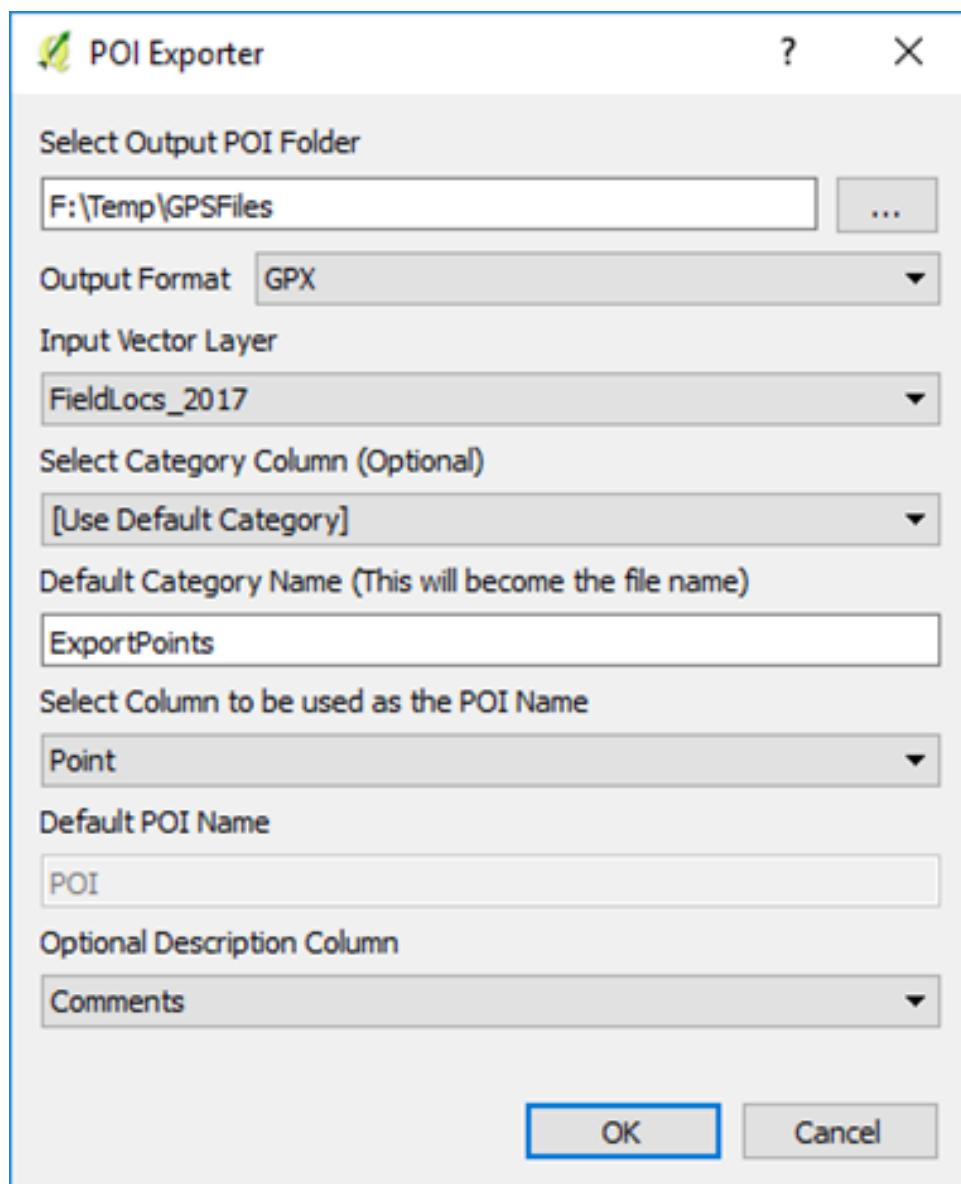
**Don't forget to save as "default" to save the styling information!**

## 7.11 Importing and Exporting GPS Data

To import points and tracks from a gpx file collected using a GPS unit, use the Data Source Manager and the GPS tab, select the gpx file to upload and the data type (tracks or waypoints). After you have imported the point or track file to QGIS, save it as a shape file to enable editing of this data.



To send data to your GPS device, use the POI (“point of interest”) plug-in. The plug-in allows you to select the layer you want to upload, the column containing the point names (or ids) and an optional comments column (up to 254 characters). The plug-in creates a gpx file which can then be easily uploaded to your gps via a direct file transfer or GPSBabel (for older models). The projection of the layer does not need to be in WGS84. Select the folder where you want the file to go, select the layer to export as a gpx, enter the filename in the “Default Category Name” box, then select the column to be used as the “POI” name. The “Optional Description Column” can be used to upload other columns such as a site description into the “Comment” and “Description” fields of the gpx file.



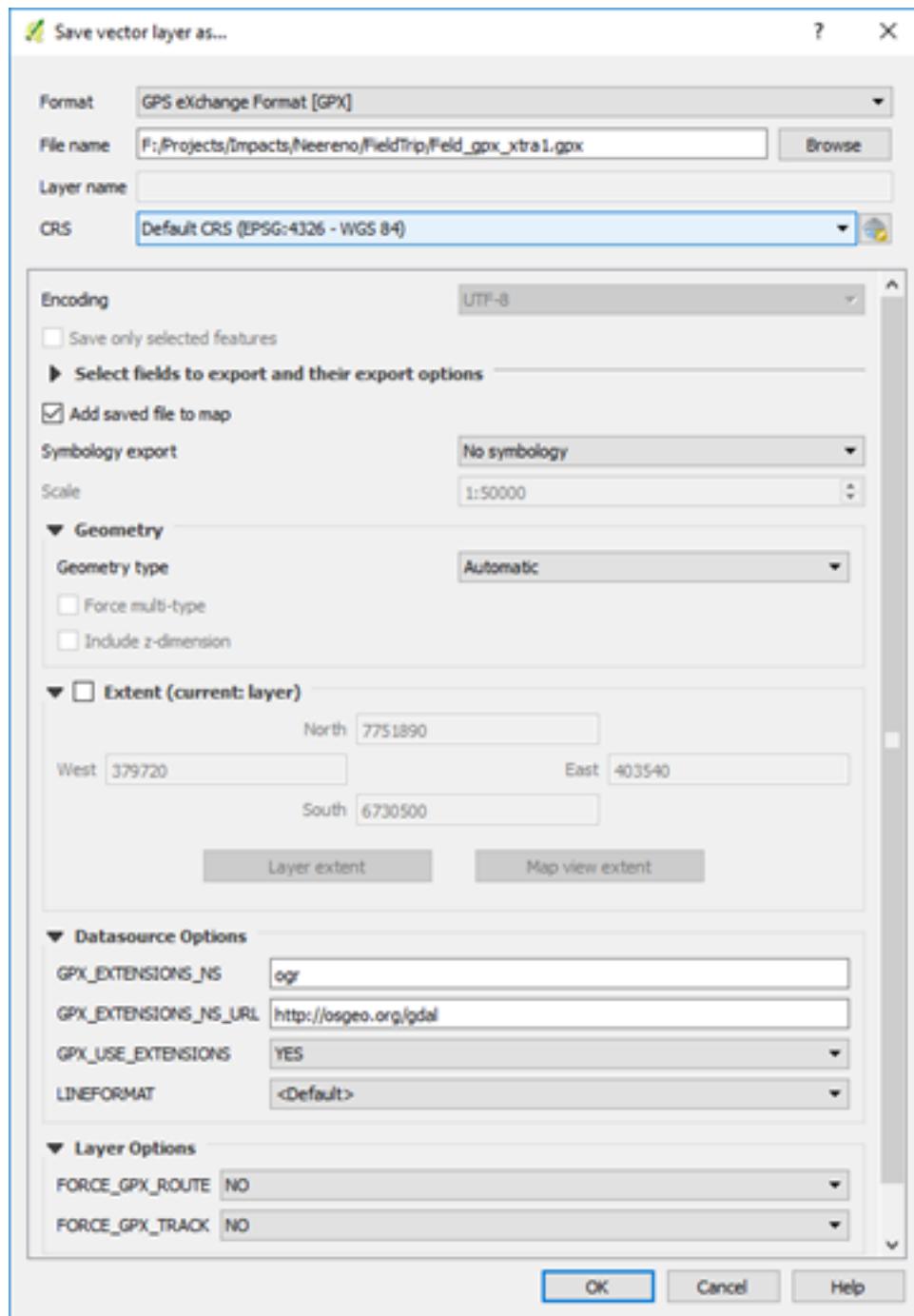
If you have problems with the gpx files, you may have to download the free “GPSBabel” utility or purchase the [GPS Utilities program](#), US\$60. The GPS Utilities program has a vast array for GPS formats that you can read or write. After you imported the GPX file into QGIS, remember to save the GPS layer as a shp file to allow for editing of the data.

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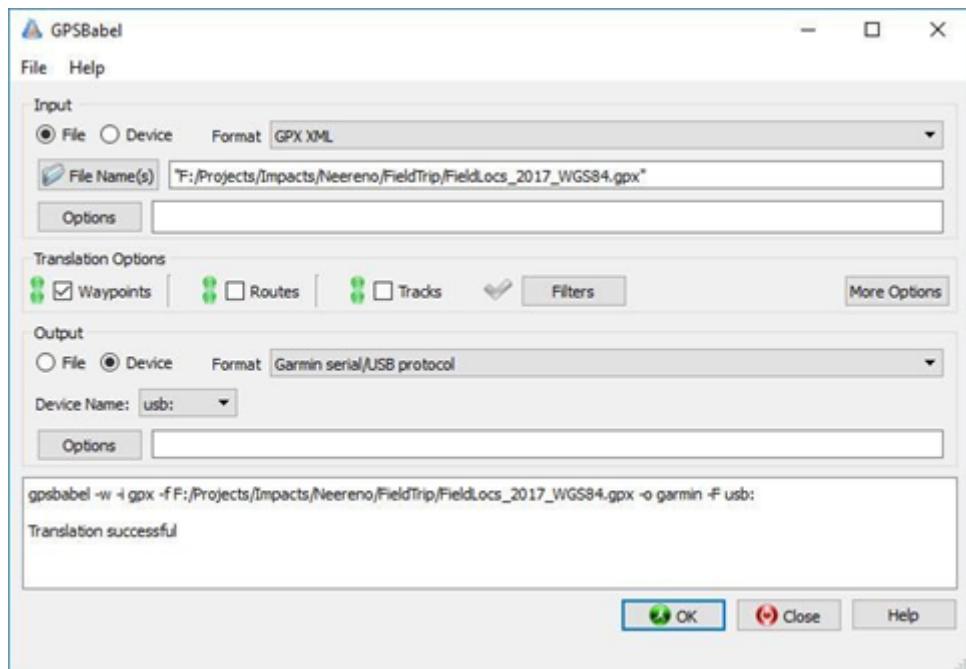
**Note:** When uploading points to a GPS via a gpx file, you may need to save the shape file in a WGS84 (Lat/Long) projection and add two new text fields for “Name” and Desc”. To include a long description in the DESC (Description) field, such as an outcrop observation, ensure you make the string length to be 254 characters. Some GPS units will only display a certain number of characters, for example the Garmin etrex Vista C only displays 30 of the 254 characters.

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Copy your point id's from your location reference column into the “Name” field using the attribute table. Do the same to copy any comments into the “Desc” field. Save the shapefiles as a gpx file with GPX USE EXTENSION “YES” before uploading to the GPS. The point id's will then appear as your waypoint names and the comments will appear in the notes section.



Open GPSBabel and select the gpx file to be uploaded, check Device “Garmin serial/usb” and device name “usb”.



The lower window will confirm if the upload has been successful.

A live link to your GPS can be accessed via the View > Panels > GPS Information panel with various connection, display, and digitising options. This allows the user to have QGIS running and a live map link via the gps.

## 7.12 Using the GSWA WAROX and WAMINES data

The WAROX (2019 edition) database contains the GSWA field locations, sample sites, outcrop photos and petrography reports. The Microsoft Access database supplied by the GSWA contains pre-defined queries to make it easier to access the data. The query “qry\_detailed” allows the user to extract the GSWA observation sites and “qry\_summary” indicates if photographs have been taken of outcrops. The query “qry\_photos” contains the photo information. Note the location of the photos is in the LocationID field and needs to be joined to the “qry\_summary” to assign a location to each photo. To import this data into QGIS, export the query as a csv (qry\_detailed.csv), ensuring you select the first row as field names, and then import this into QGIS via the CSV import option. Change the projection to GDA94 from the default WGS84. The Access queries can also be modified to allow the extraction of observation sites with photos only.

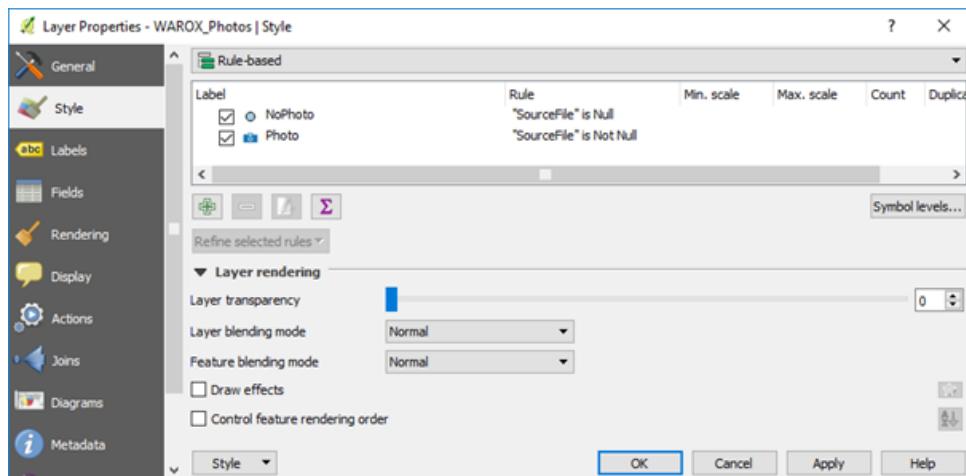
In QGIS, open the layers attribute table, make editable and add another column (called something like “SourceFile”) of type string (text) with width of 100 characters. Save this update. This “SourceFile” column will hold the file location and photo number that will allow QGIS to display the photo for this location. The next step will concatenate the directory path and photo file name into the “SourceFile” column.

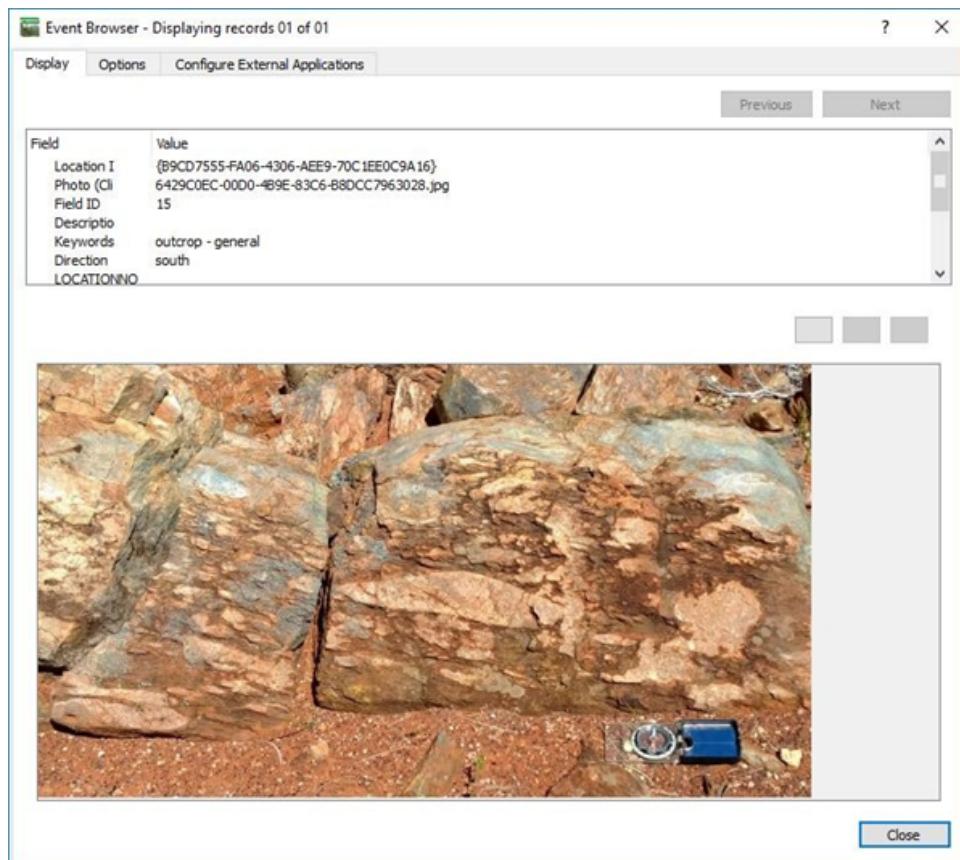
Click in the column selector to select the “SourceFile” column and then enter the following expression in the expression editor “concat(‘directory location’||”SourceFile”) substituting the directory location to point to where you have saved the WAROX photos. Note you need to change the default back slash () to a forward slash (/) in the directory path or you will get “?” replacing the back slashes. Save the file.

WAROX_Photos :: Features total: 44137, filtered: 44137, selected: 0					
	LOCATIONNO	SITEID	DLAT	DLONG	SourceFile
1	455490	RHSMUG001857	-25.9680700000...	127.8175499999...	F:/Projects/WA/WAROX/PHOTOS/WAROX/E7415948-F660-4E5C-8980-AAF6D5CDFB8C.jpg
2	533013	RHSMUG002498	-26.1122500000...	127.4201400000...	F:/Projects/WA/WAROX/PHOTOS/WAROX/64E74152-6977-4ED8-8FA0-37A46DC84508.jpg
3	533013	RHSMUG002498	-26.1122500000...	127.4201400000...	F:/Projects/WA/WAROX/PHOTOS/WAROX/64E74152-6977-4ED8-8FA0-37A46DC84508.jpg
4	505528	RHSMUG002283	-26.1214599999...	127.5252100000...	F:/Projects/WA/WAROX/PHOTOS/WAROX/30A6805E-43C8-4FAE-B1FA-FA0F4B62363D.jpg
5	416288	PMEMUG000523	-25.6377600000...	128.1871399999...	F:/Projects/WA/WAROX/PHOTOS/WAROX/8EB85D81-1FCA-4486-8D1D-9FBF36864606.jpg
6	416288	PMEMUG000523	-25.6377600000...	128.1871399999...	F:/Projects/WA/WAROX/PHOTOS/WAROX/91099019-1FDA-498F-8A0A-9008AF450764.jpg

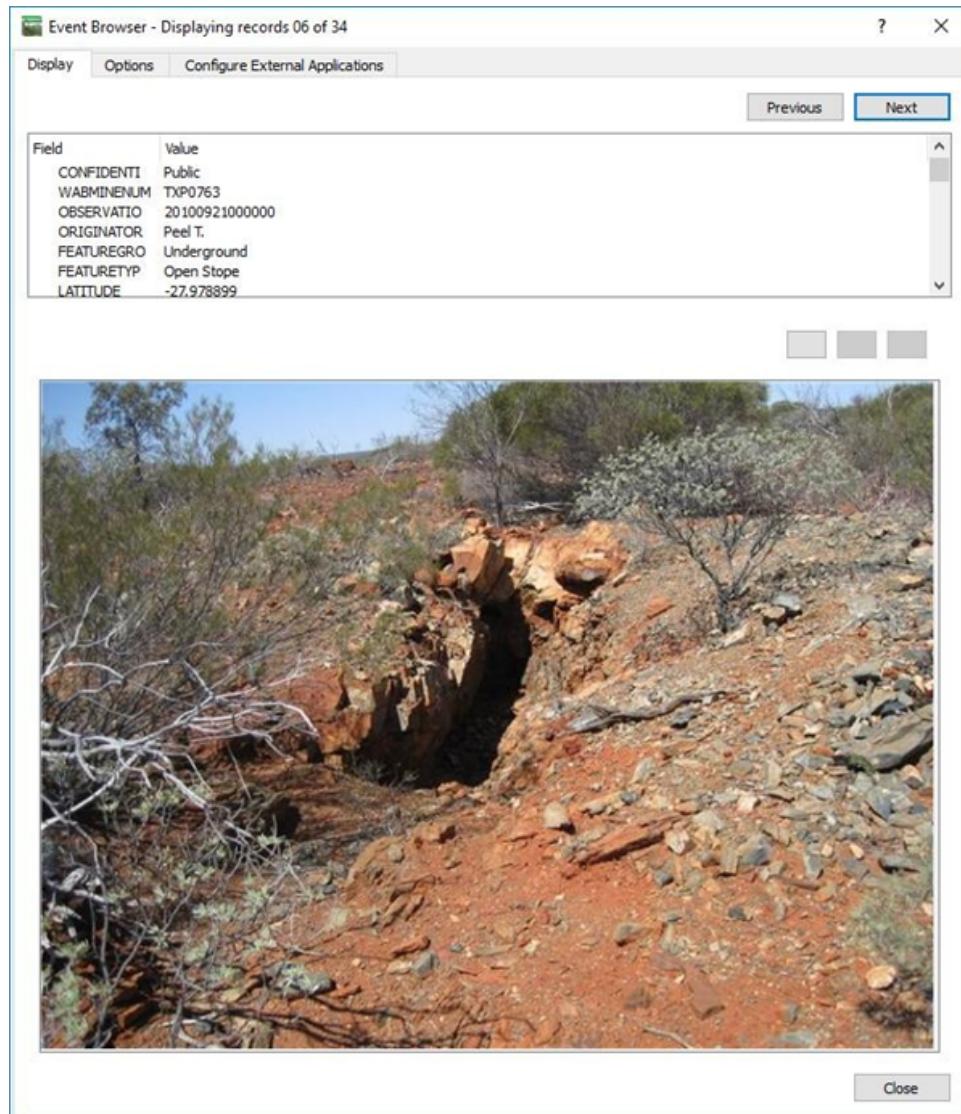
You may want to Categorise the points into those with and without photos using a “Rule based” styling using photo SourceFile is Not Null for points with photos (meaning there is a photo link), and no photo when SourceFile is Null (no photo link). I have used a photo icon to indicate if there is a photo available at a particular location.

Use the methods above to display photos linked to that site. The Action properties for the layer can also be used to display photos. An example below shows the WAROX points displayed to indicate whether a photo was available at that location.

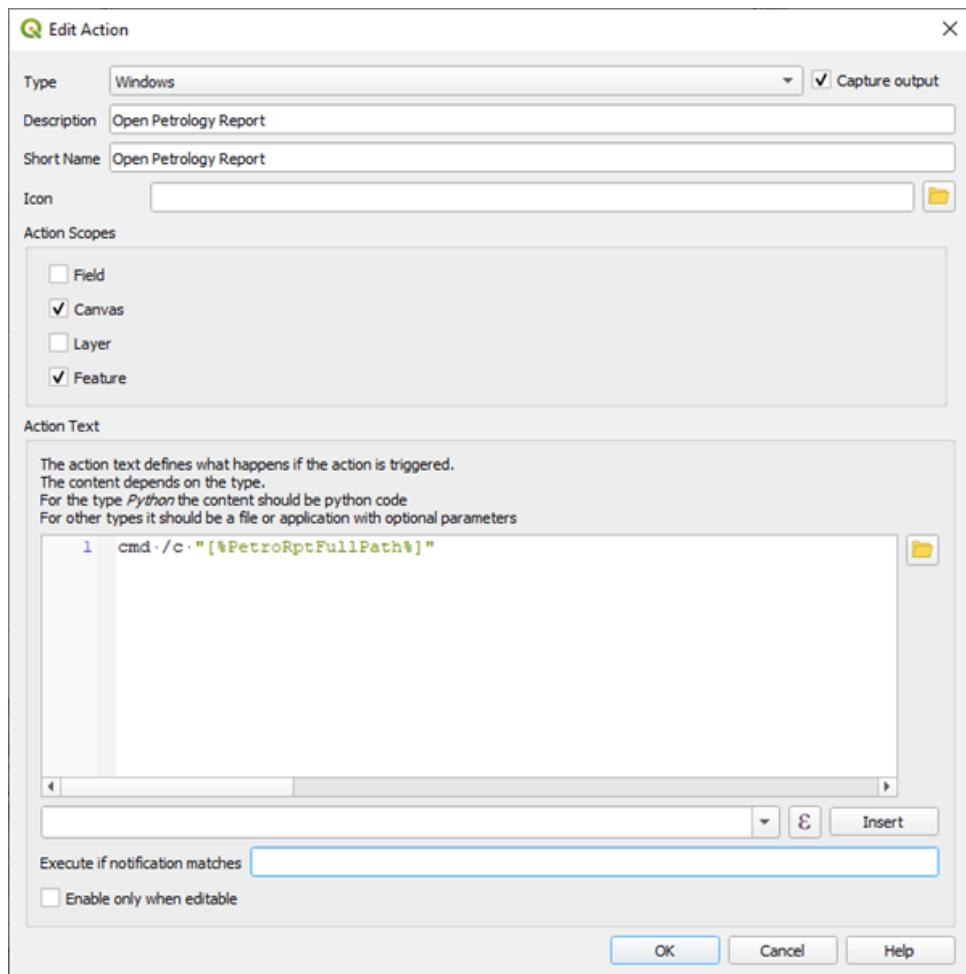




A similar process can be used to display linked petrographic reports and photos in the WAMINES database. See below an example from the WAMINES database. To display pdf files, you will need to add the pdf display program in the “Configure External Applications” tab.



PDF files can also be displayed via the Action tab, add the cmd /c command to the action text.



## 7.13 Creating and converting Local (Non-Earth) Grids to Real World Coordinates

The Geoscience plug-in allow you to create a custom CRS. For this you will need at least three points in both coordinate systems, better to have four and enter 0 for any Z values. This plug -in will create a WKT (“Well Known Text”) file that can be used to create a custom CRS in QGIS under the Settings > Custom Projections tab.

There is no easy way to convert non-earth coordinates but there is a way by using the v.transform algorithm. The algorithm requires an x, y coordinate for the grid origin and an optional rotation amount. This data should be available from the mine surveyor or can be calculated. The author uses a small python program that uses 2 common sets of points to calculate a grid origin and rotation amount. The workflow below is for point data and within one UTM zone in metre coordinates only. If you would like a copy of this python code, please contact me.

Using a new project workspace, change **project projection** to “no projection” then open the local grid file using the local coordinates (e.g. drill holes in local coordinates). Check that the local coordinates in the map window look correct.

Run the v.transform algorithm with the points in local grid coordinates. To find this algorithm display the Processing Toolbox in the RHS of the map window, type v.tr in the search box and the v.transform algorithm should now be displayed. Double click on it to open the v.transform dialog box. Use the parameters for x, y and rotation.

Allocate the new projection to the points by **firstly**, setting the projection of the transformed layer to your desired UTM projection (**very important to do this first**) via the Layer Properties > Source tab, then change the project projection to your UTM projection. Close the original local coordinates file and zoom to the extent of the new transformed layer to check the transformation was successful.

This will produce a transformed (virtual) layer which will need to be “Exported As” to save the file permanently.

## 7.14 Creating a Grid Layout

A regular grid of points can be created via a table of coordinates or using the “Regular Points” algorithm. Other create grid options are available in the Processing Toolbox, but these two methods are the simplest.

To create a grid, from a table of coordinates, use the “Create points from Table” algorithm located in the Processing Toolbox under the Vector Creation list. Input the table that contains the coordinates, select the X and Y coordinate fields, with optional Z and M fields as well, check the CRS and run. The algorithm will create a series of points with id’s only. Use the attribute table to add Easting and Northing fields if desired to attach the point coordinates.

To create a grid of points using the map window, use the “Regular Points” algorithm in the Vector Creation list. The extent of the grid can be entered manually or defined by the map window extent. Set the grid spacing and check the CRS and run. The resulting grid can be rotated (using the Vector Geometry > Rotate algorithm) or the “Rotate Feature” on the map window icons (next to the “Move Points” icon). Both methods allow the user to select the point for rotation and the amount of rotation.

---

**Note:** If you want to create non-square or hexagonal grids, for example, use the “Create Grid” option under the Vector Creation options.

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## 7.15 GeoPackages

The following is from the Open Geospatial Consortium (OGC) website.

*GeoPackage is an open, standards-based, platform-independent, portable, self-describing, compact format for transferring geospatial information.*

*The GeoPackage Encoding Standard describes a set of conventions for storing the following within an SQLite database:*

- vector features
- tile matrix sets of imagery and raster maps at various scales
- attributes (non-spatial data)
- extensions

*To be clear, a GeoPackage is the SQLite container and the GeoPackage Encoding Standard governs the rules and requirements of content stored in a GeoPackage container. The GeoPackage standard defines the schema for a GeoPackage, including table definitions, integrity assertions, format limitations, and content constraints. The required and supported content of a GeoPackage is entirely defined in the standard. These capabilities are built on a common base and the extension mechanism provides implementors a way to include additional functionality in their GeoPackages.*

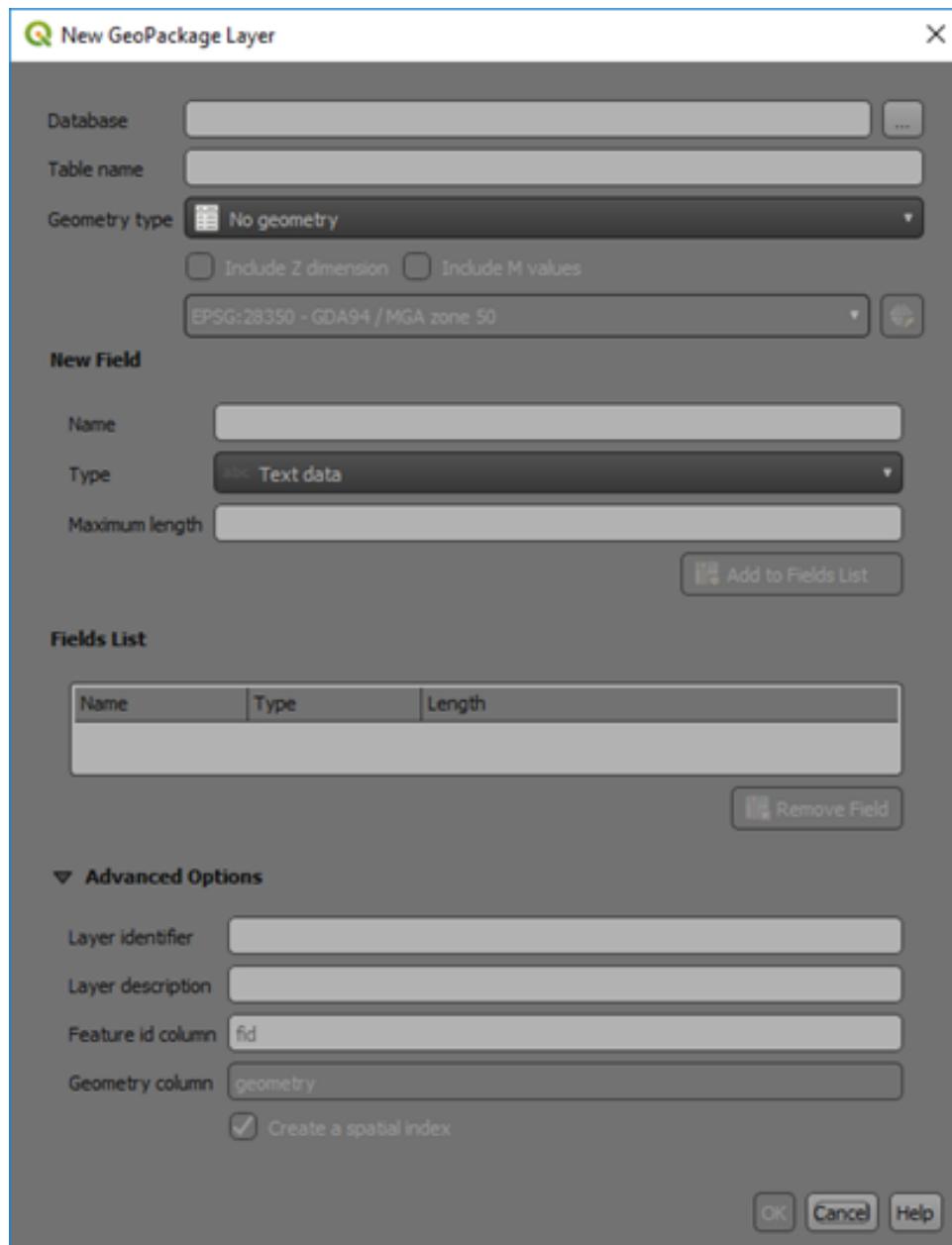
What all this means is that you can create a GeoPackage with vector data containing point, line and polygon data with their respective styling, and also include raster data files.

Field names are not restricted to 10 characters, as is the case with shapefiles.

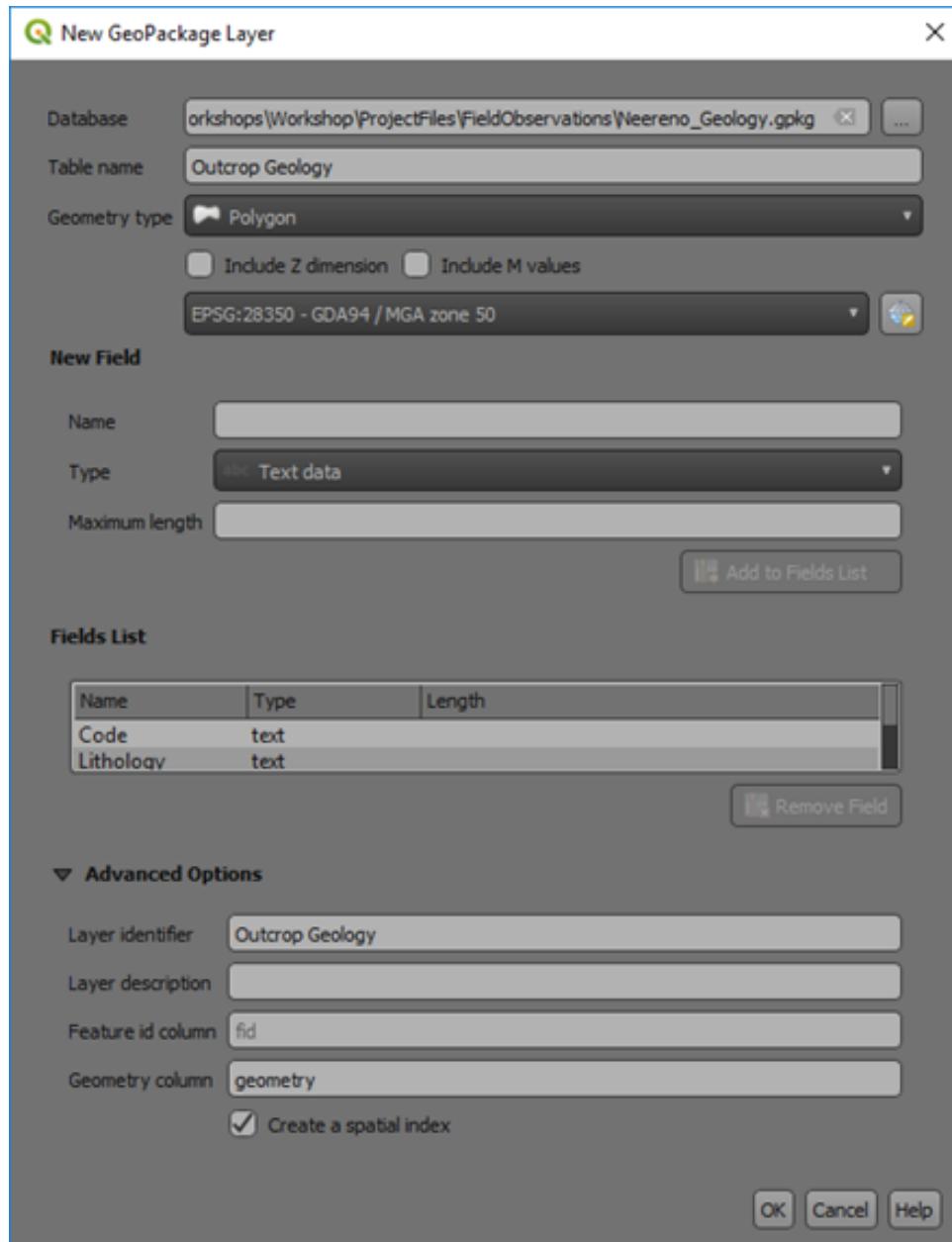
GeoPackages can be used to transfer complete projects with all the data and display attributes - see the end of this section for details. When digitising into a GeoPackage file, the id field is automatically incremented. The data is spatially indexed so panning and window refreshes are much faster.

GeoPackages have a .gpkg file extension.

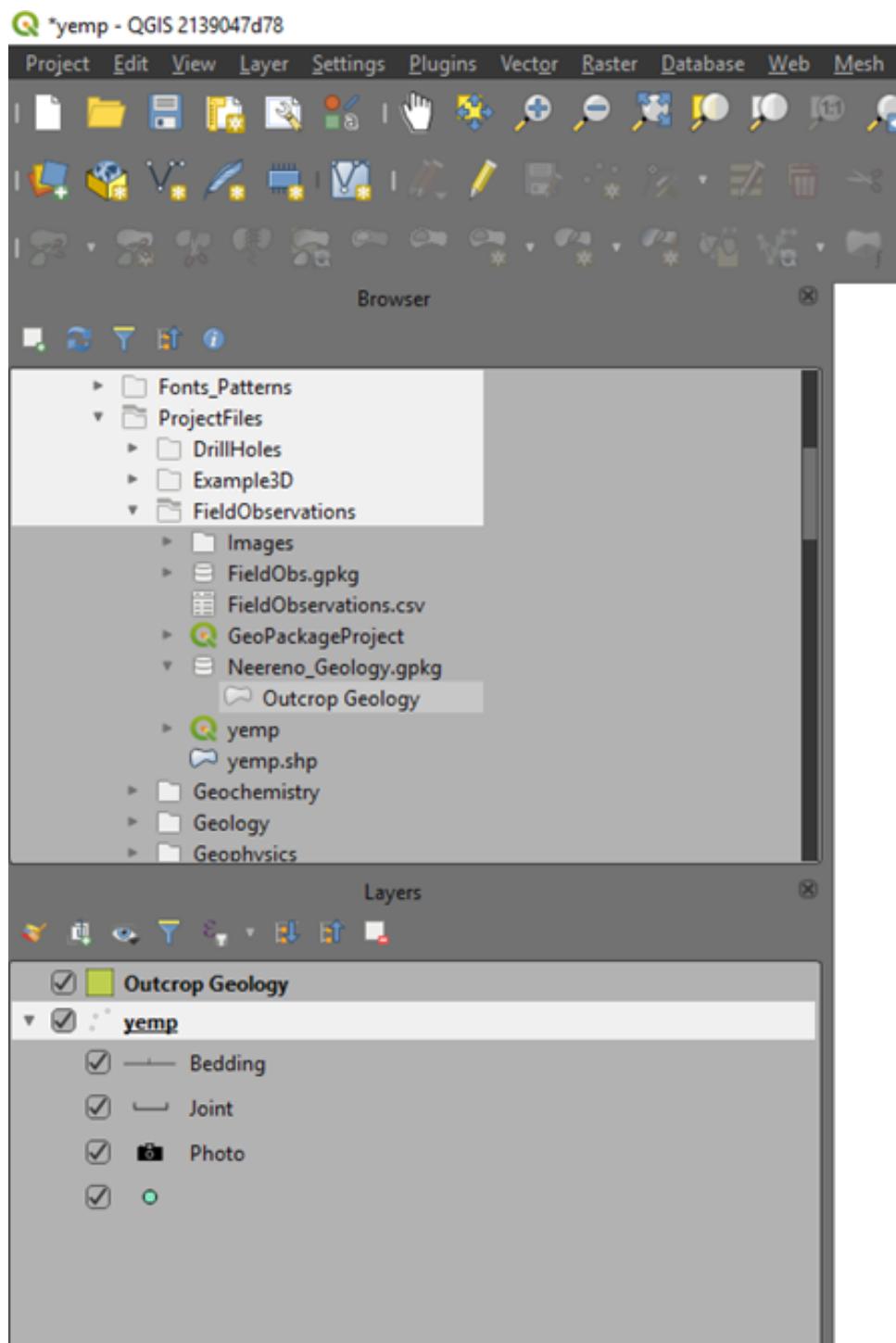
To create a new blank GeoPackage, use the Layers > Add New Layer and select GeoPackage. The following dialog box will appear.



The database name will be the new GeoPackage name and make sure you selected the three dots to the right of the entry field to ensure you know where it will be saved. The table name will be the layer within the GeoPackage. Ensure you select the correct geometry for the layer and the correct CRS of the data. Add your required fields for the table/layer and press OK to create a GeoPackage.

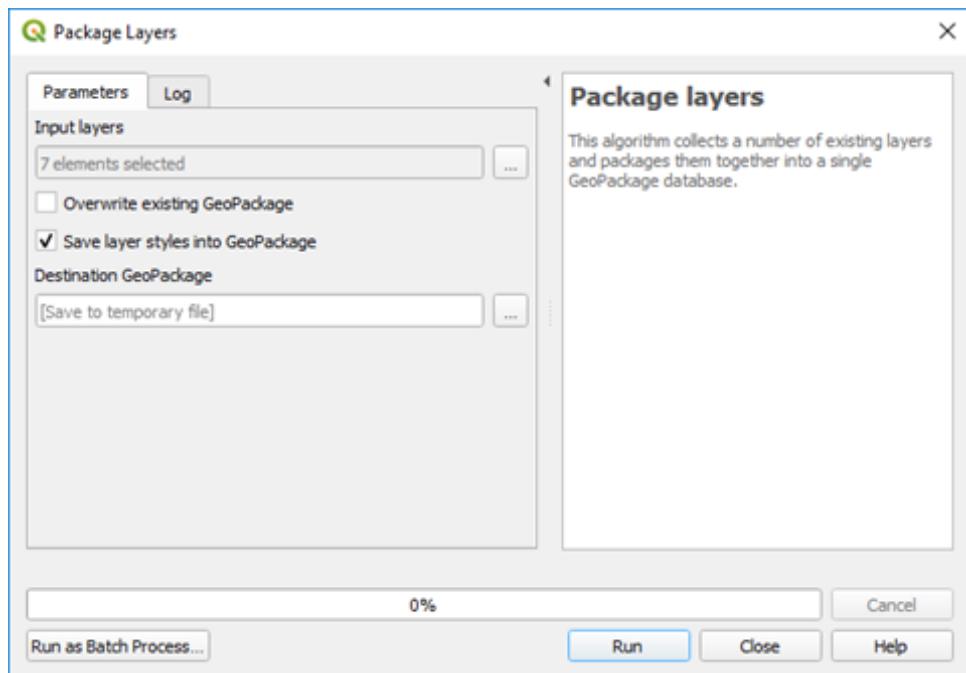


Once a GeoPackage has been created, shapefiles in the layers panels can be selected and dragged into the browser panel and added to the GeoPackage file by overlying the layer on the GeoPackage name (a small plus symbol will be displayed when overlaid in the correct place).



GeoPackages can also be used to store complete projects. Currently this requires three steps.

Firstly, use the Processing Toolbox > Database > Package Layers algorithm to package all the vector layers into a GeoPackage - this algorithm only saves the vector layers. Ensure you tick the “Save layer styles into GeoPackage” (only available in versions 3.8 and higher).



The next step is to drag the raster layers into the new GeoPackage, then close the original layers.

The last step is to re-open them using the GeoPackaged files. Reorder the layers as required and save the project into the same folder as the GeoPackage.

You will then have a GeoPackage file **\*.gPKG** and an associated project file (**\*.qgz**) which when moved together will be the complete project data package.

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**Note:** GeoPackages can only be edited by single-user at a time.

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# CHAPTER 8

## DISPLAYING GEOCHEMICAL DATA

### 8.1 Importing and Styling Geochemical Assay Points

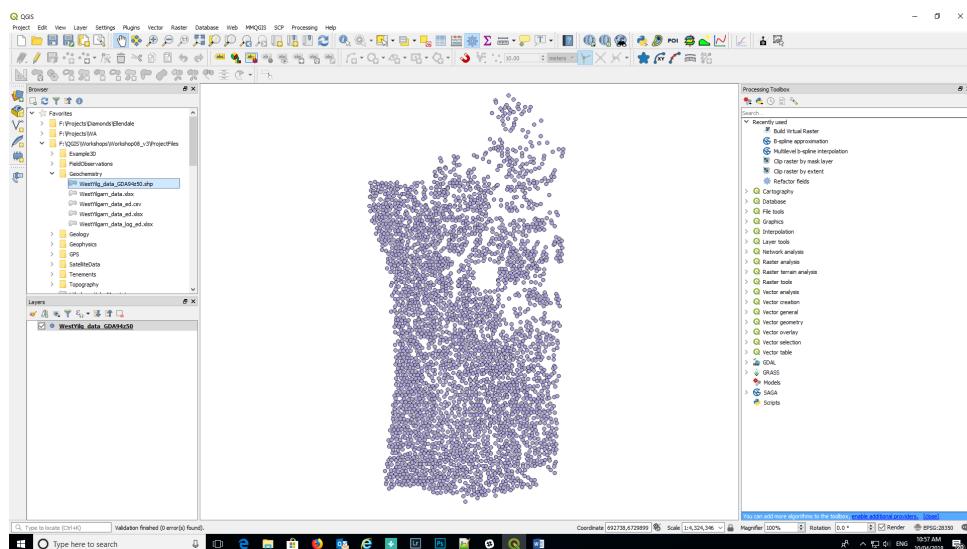
Geochemical data is usually in the form of an excel spreadsheet or as a text file. Open the file in QGIS via the “Spreadsheet Layers” or CSV file open options depending upon the format of your data. See section 6 above for opening spreadsheet and csv files, and the potential use of CSV format files (\*.csvt) for large complicated csv files. If you have problems importing large csv files exported from Excel, save the file as a tab-delimited text file and import this into QGIS.

IoGAS has created a QGIS plugin for its export files and can be downloaded from the [ioGAS website](#). This provides a live link between QGIS and ioGAS.

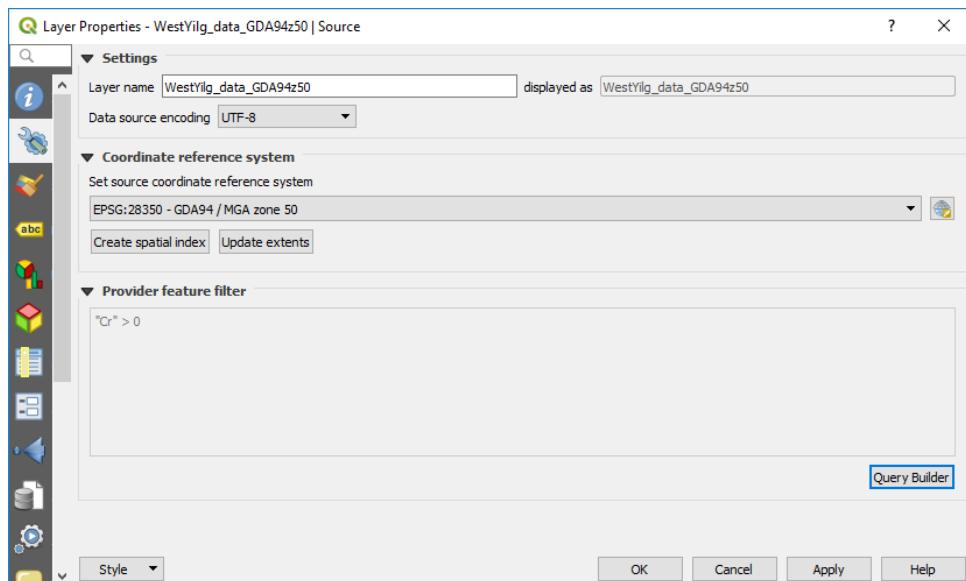
When loading your data, ensure the data has been loaded into QGIS as the correct field type, i.e. as a number, not as a string (text) field. This can be checked using the layer’s Layer Properties > Fields tab.

When the data has been imported into QGIS, make sure you check the correct coordinate system has been selected.

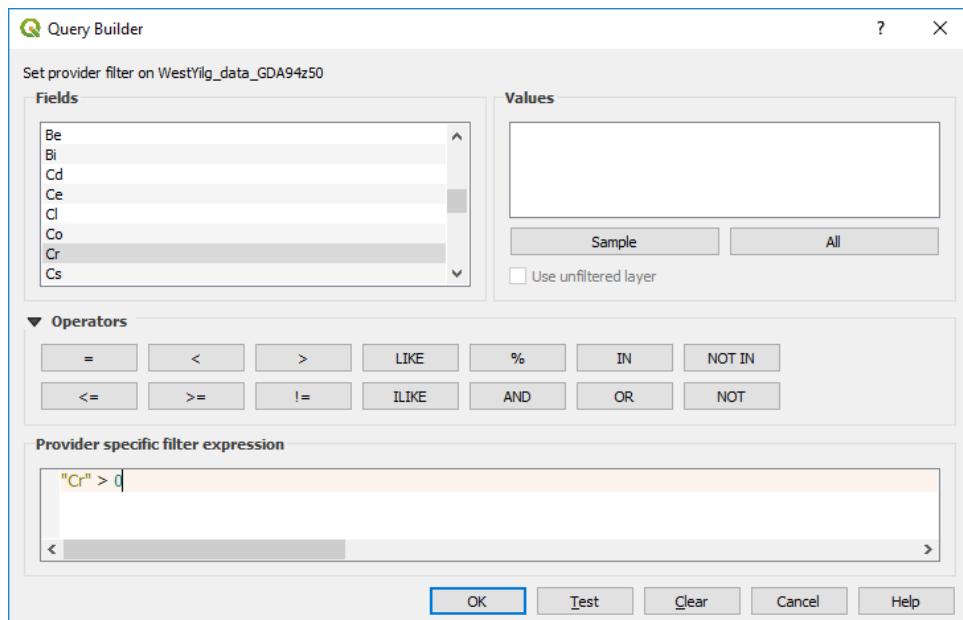
Use the View > Statistical Summary option to display the statistics for a particular field. This helps to identify potential problems with the data such as negative values representing below detection limit data. Geochemical point data can be displayed as points and can be coloured or sized according to value.



To filter out bad data, use the “feature filter” in the Source tab of the Layer Properties to filter out all the negative numbers (below detection or not assayed) - see the following image as an example for the Cr data.



Use the query builder, as shown below. Note that this has only been done for Cr values in this example.



This is important for geochemical data so the negative values do not influence the statistics of the data.

Univariate statistics can be calculated using the View > Statistical Summary panel. This opens a panel under the browser panel, where you can select the layer and data field for which field you want to calculate statistics. The mean, standard deviation, first quantile, third quantile and the Inter Quartile Range (IQR) are among some of the calculated results.

To examine the statistics of the data, use the View > Statistics Panel and select the field to be queried.

Statistics

WestYilg\_data\_GDA94z50

1.2 Cr

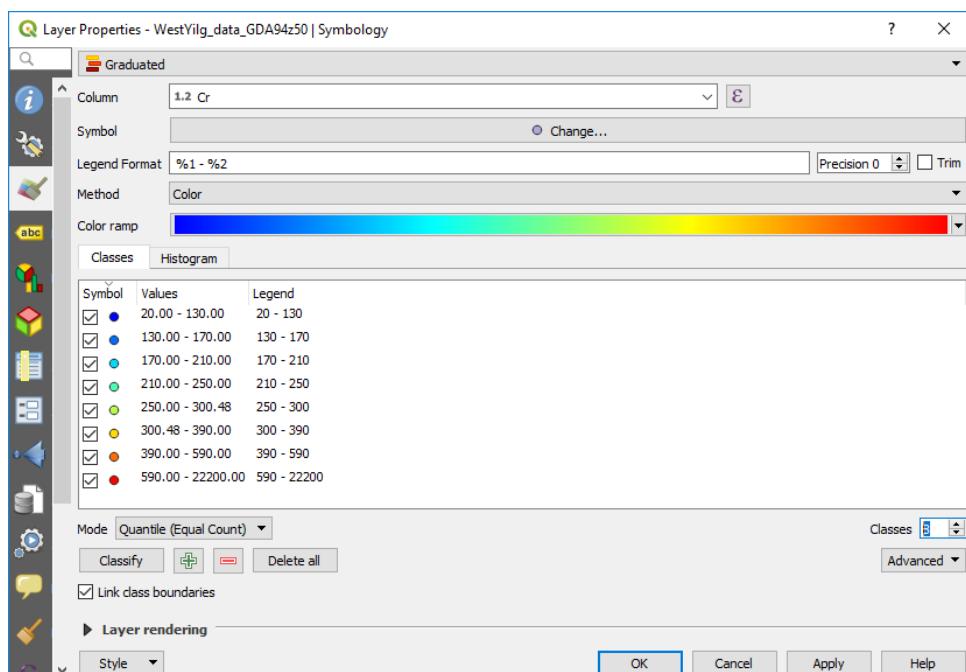
Statistic	Value
Count	3141
Sum	1.498e+6
Mean	476.919
Median	250
St dev (pop)	1195.39
St dev (sample)	1195.58
Minimum	20
Maximum	22200
Range	22180
Minority	109.439
Majority	160
Variety	290
Q1	170
Q3	390
IQR	220
Missing (null) values	0

Selected features only  

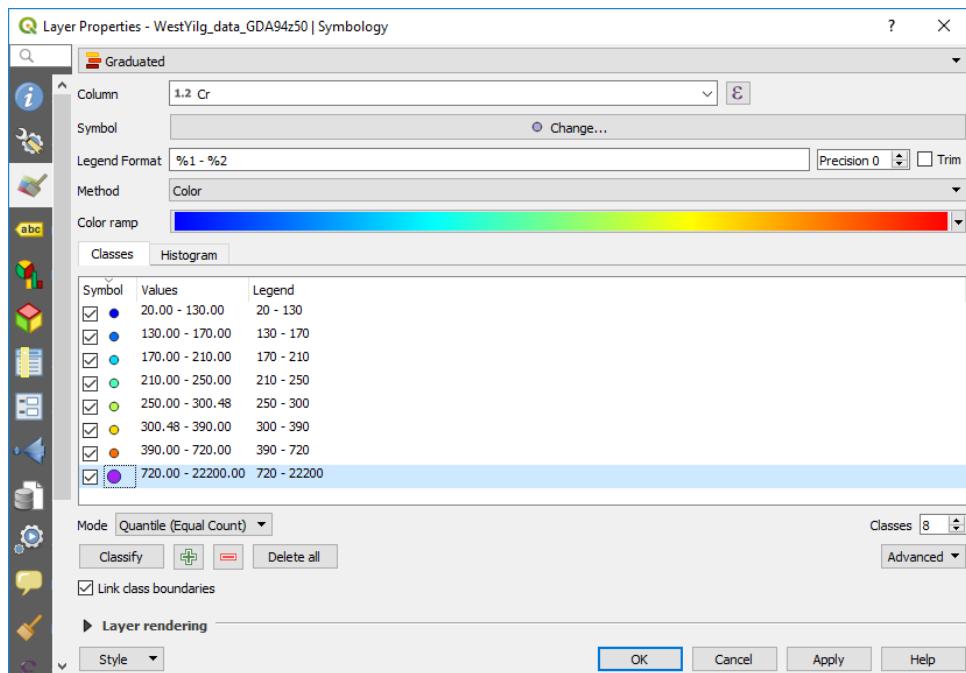
In this example note that the first and third quantiles are 170 and 390 ppm Cr with an IQR (inter quartile range) of 220. Geochemists would say that any values over 720 ppm Cr ( $Q3 + (1.5 * IQR)$ ) are anomalous.

To colourise your data, use the Layer Properties > Style tab to select the way you want the data displayed. The simplest way is to use the “Graduated” option and colour the point values. Note that this works on numeric values only. Select the column you wish to colour the points by and the desired colour ramp and hit the “Classify” button. Under the display window, you can also select the way the points are coloured. You can use a variety of methods. You can also manually edit the ranges in the display window.

To colour the geochemical data by assay value, select the Style tab in the layer properties panel. Select the Graduated option in the top drop-down box. Select “Cr” as the field to be displayed. Select a suitable “colour ramp”, select Mode “Quantile (Equal Count)”, change Classes to 8, hit “Classify” (if you forget to hit Classify you will not see any colours!). You will note that the boundary between the second and third quantile is 170 ppm (Q1) and the boundary between the sixth and seventh range is 390 ppm (Q3). Other display modes may be more applicable, and this will depend upon your data and how you want to display the data.

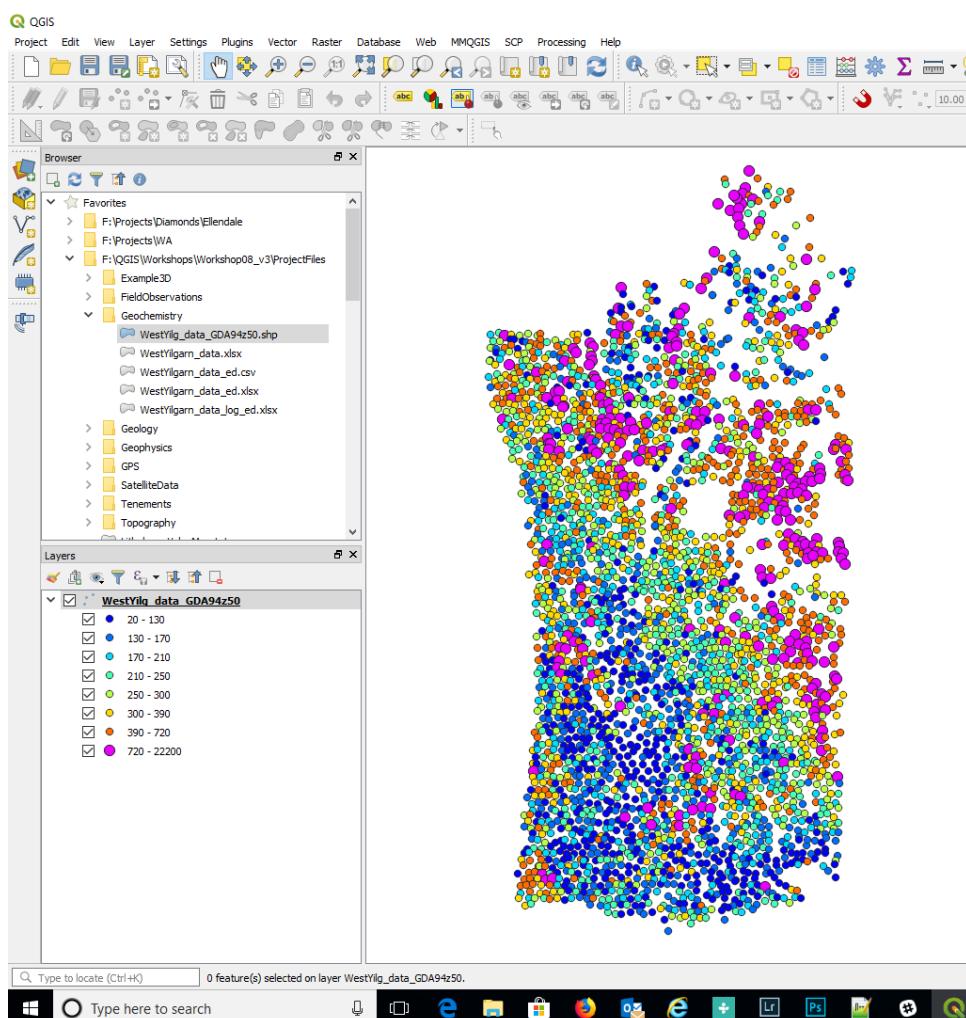


The top two classes are below 170 ppm (25th percentile) and the bottom two classes are greater than 390 ppm (75th percentile). You can manually edit the second last range so that its upper value is 720 ppm (anomaly threshold) and it will automatically update the eighth data range.

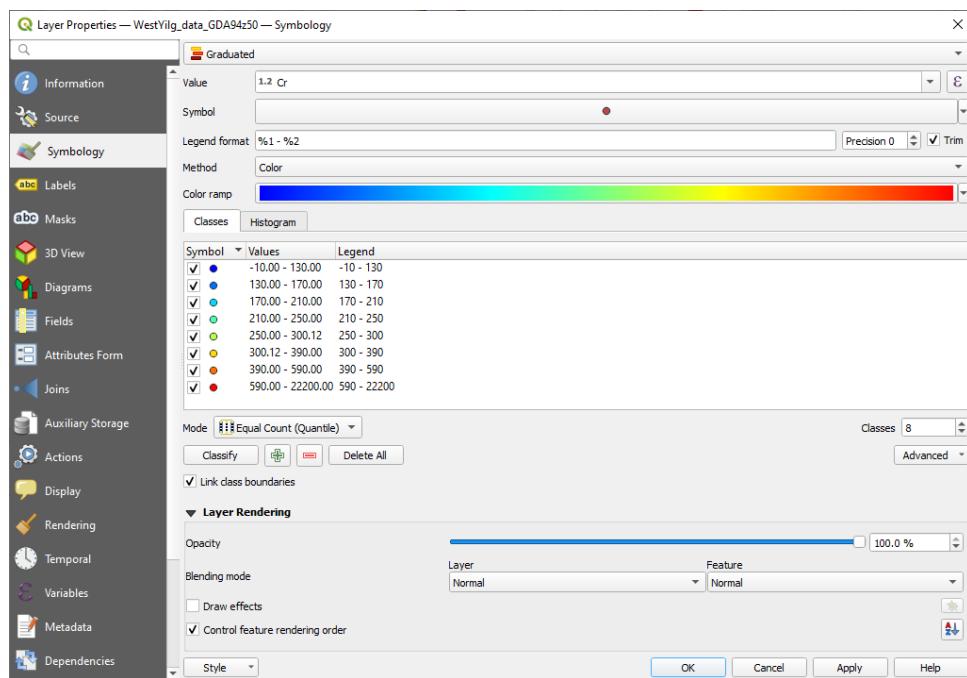


In the figure above I have selected the >720 ppm and enlarged the symbol.

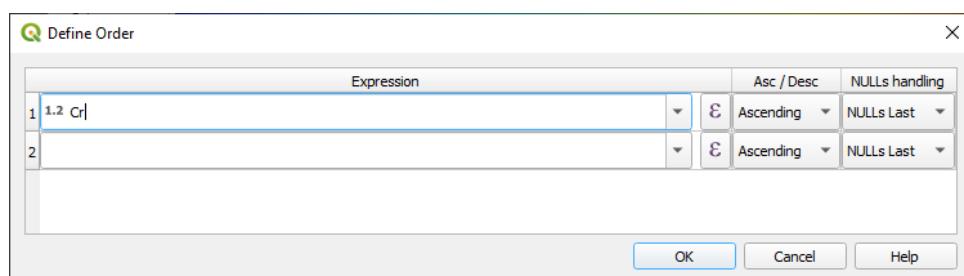
Other options are available for the display of the data - see the “Mode” drop-down box. Note you can vary the displayed number of decimal places in the legend by using the “Precision” option in the dialog box.



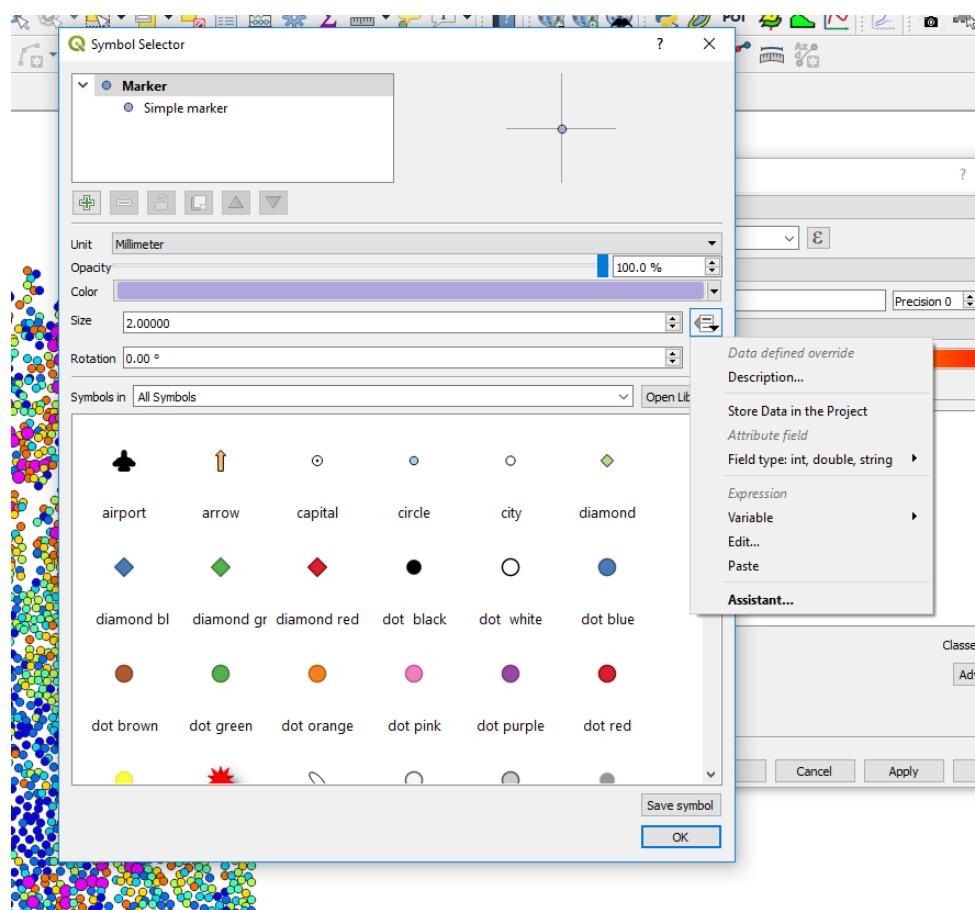
The drawing order can be varied so that all the high values are plotted on top. To do this scroll down the Symbology dialog box to the “Layer Rendering” option, turn on the “Control feature rendering order”, then click the “sort” icon on the right-hand side.

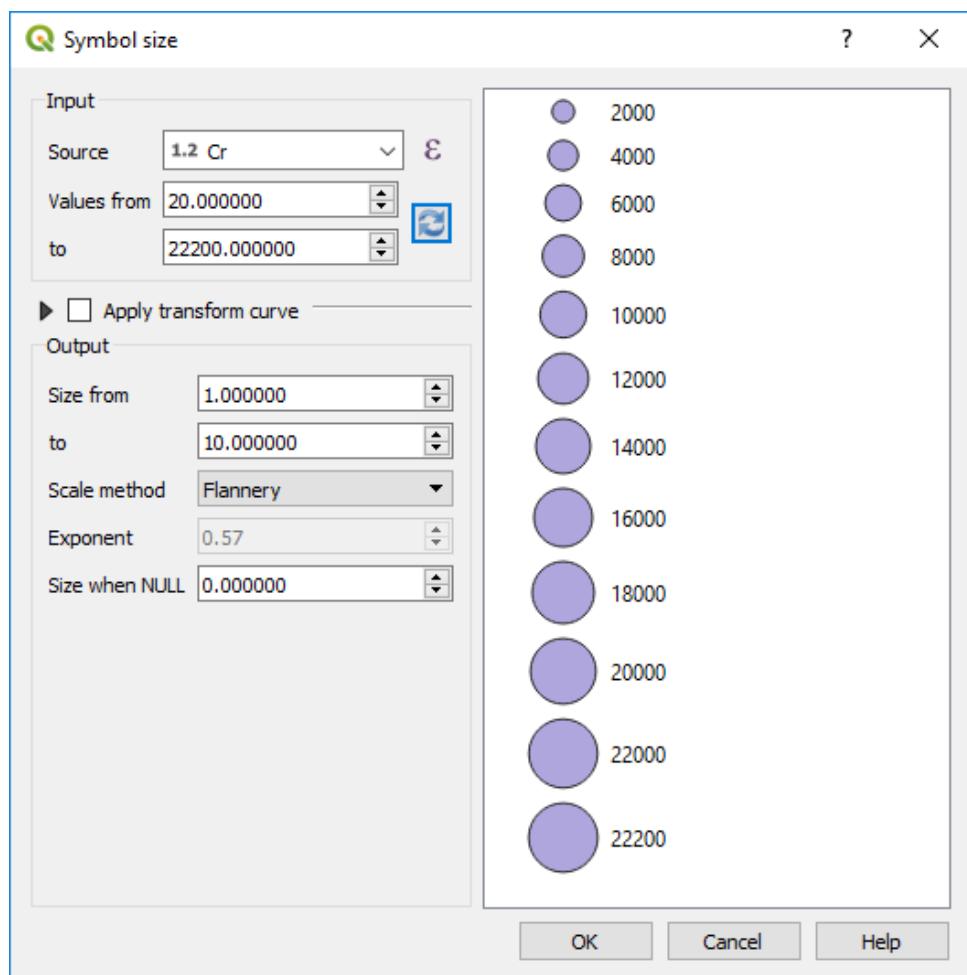


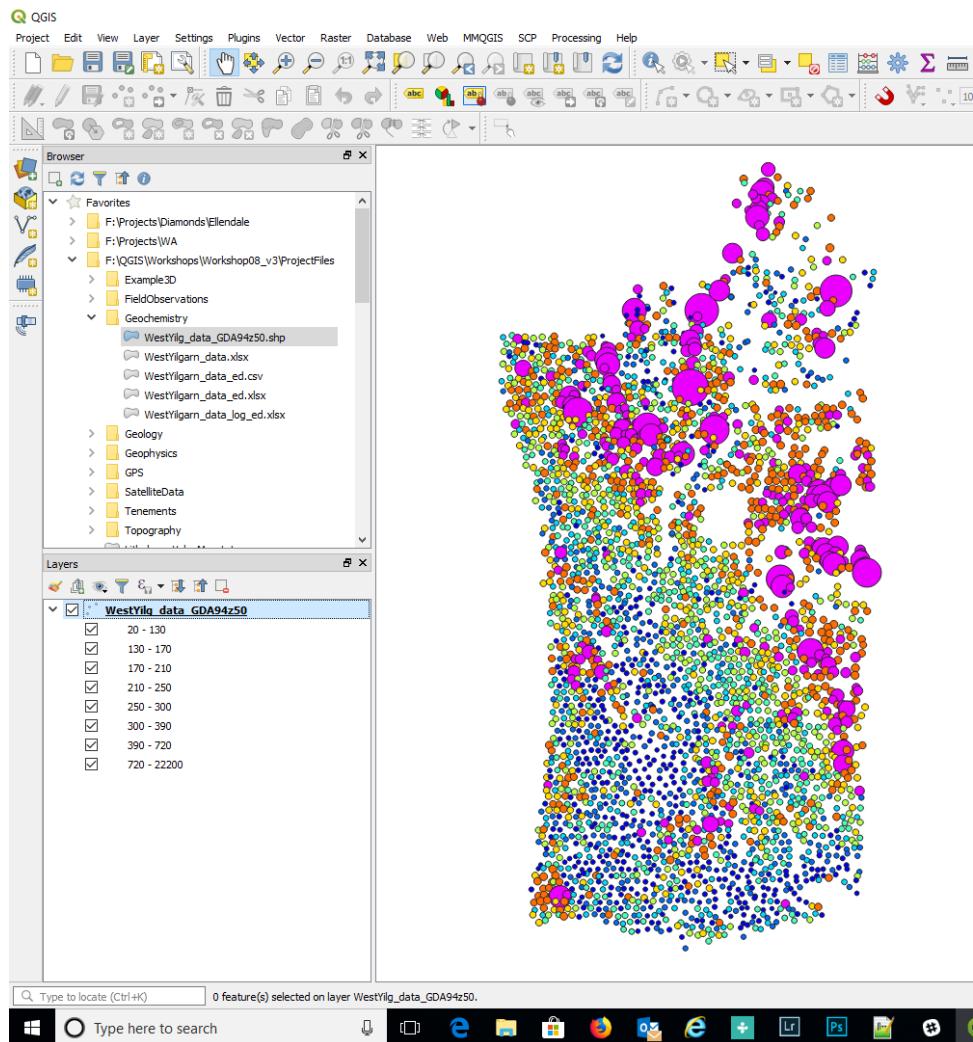
Select field to use for the ordering and whether you ascending or descending order.



Points can also be classified by size. Click in the Symbol box (where it says “change”) to bring up the symbol selector window. Highlight the “Marker” layer in the top left, then click on the far-right hand side of the Size options where there is a little square box with a down arrow. This is the “Data Driven Override” button. Click on this and scroll down to “Size Assistant” where you can select the symbol size by the field “Cr”. Select the field to use for the size, then refresh so that QGIS can calculate the data range in that field. Select OK to apply. Close the layer properties window.





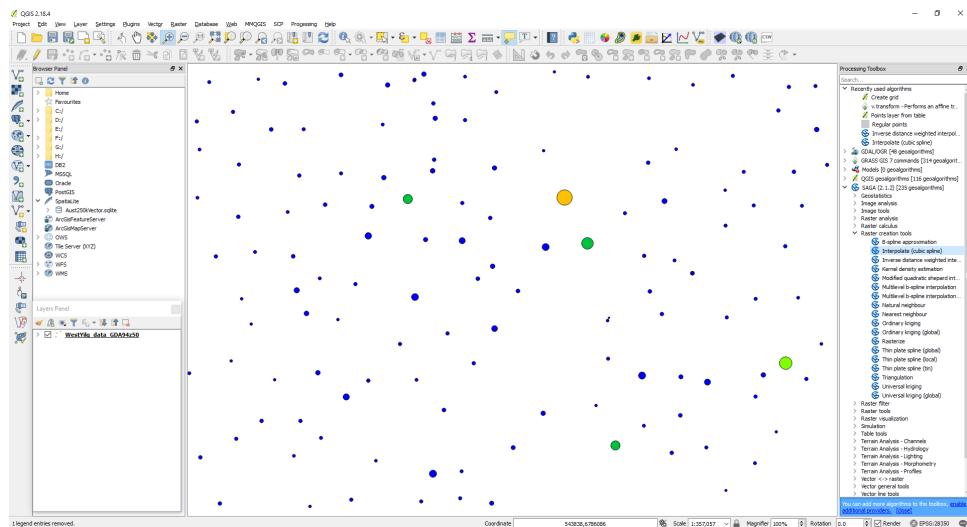


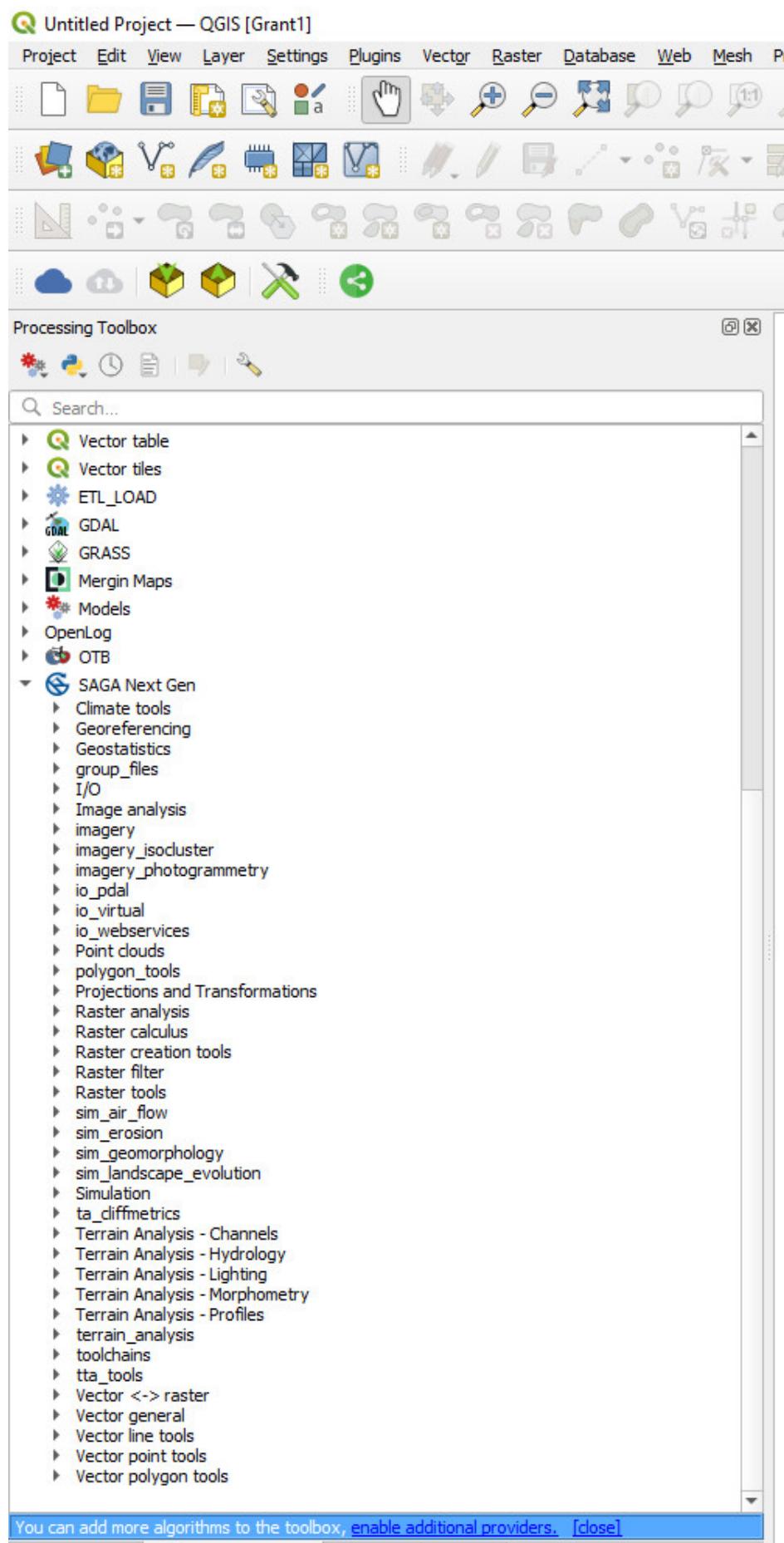
## 8.2 Gridding Surface Geochemical Data

To create a grid of the geochemical data, zoom to an area of data that you want to grid and open the Processing Toolbox > SAGA Next Generation > Raster Creation Tools > Multilevel b-spline. Note SAGA Next Gen is not installed by default and you may need to go to your plug-in manager and install/enable.

Select the field to grid and click select and enter a file name (if you want a permanent file output) and location to where you want to write the grid file. It is important to make sure QGIS can write to the folder (not the default Program Files folder), otherwise the operation will fail. Note there are many gridding options available in QGIS, this is one example.

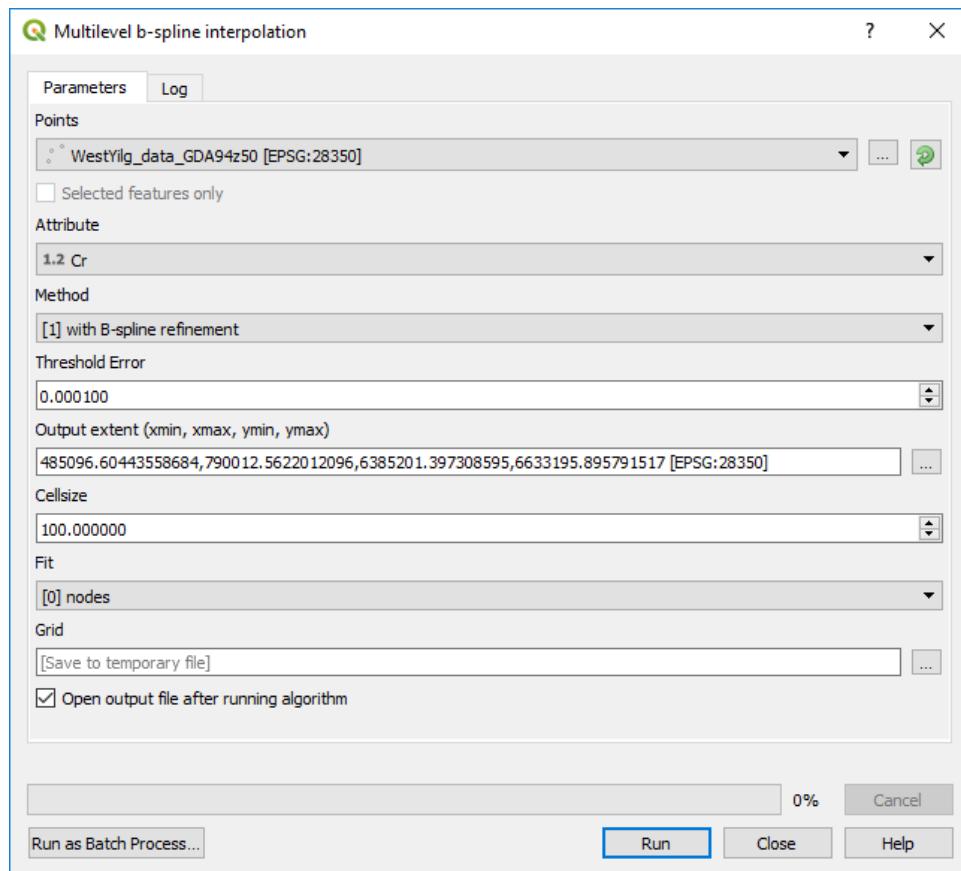
Zoom in to a subset of the data, as shown in the figure below.



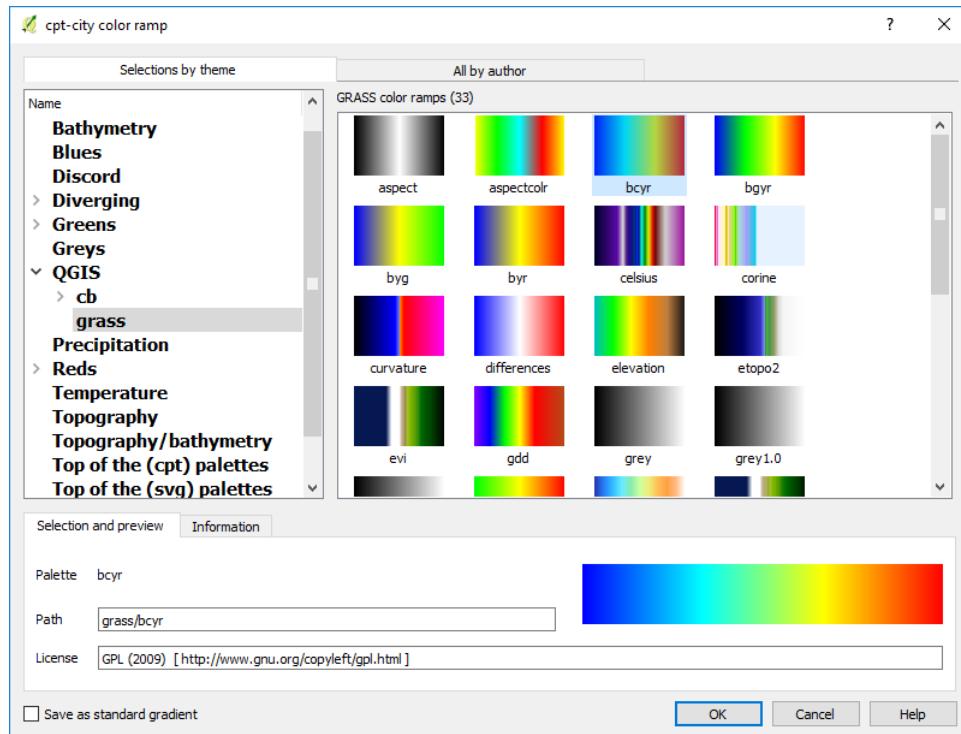


- ▶ Projections and Transformations
- ▶ Raster analysis
- ▶ Raster calculus
- ▼ Raster creation tools
  -  Angular distance weighted
  -  B-spline approximation
  -  Grid cell area covered by polygons
  -  Interpolate (cubic spline)
  -  Inverse distance weighted interpolation
  -  Kernel density estimation
  -  Modified quadratic shepard
  -  Multilevel b-spline
  -  Multilevel b-spline for categories
  -  Multilevel b-spline from grid points
  -  Natural neighbour
  -  Nearest neighbour
  -  Ordinary kriging
  -  Polygon categories to grid
  -  Polygons to grid
  -  Rasterize
  -  Regression kriging
  -  Simple kriging
  -  Thin plate spline
  -  Thin plate spline (tin)
  -  Triangulation
  -  Universal kriging
  -  Variogram (dialog)
- ▶ Raster filter
- ▶ Raster tools
- ▶ sim\_air\_flow

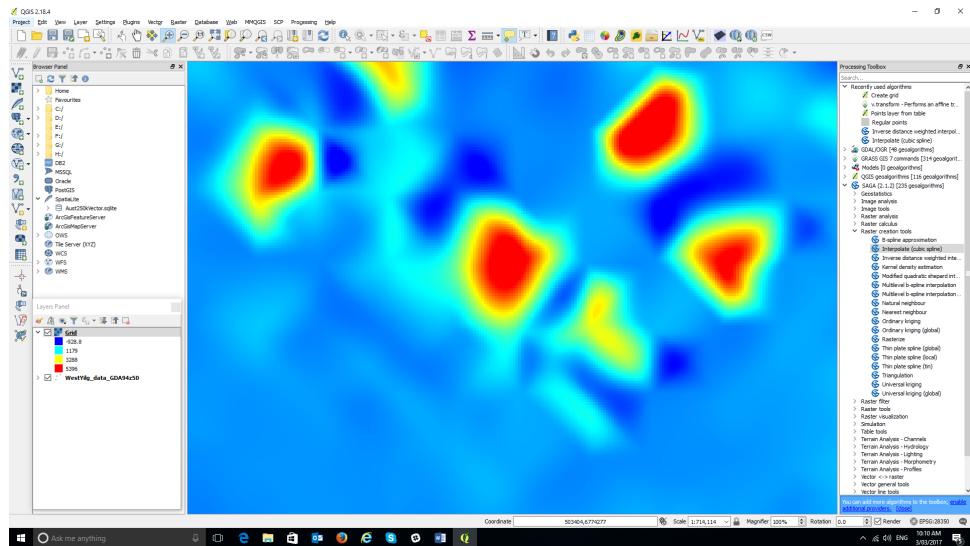
To limit the area over which the grid will be calculated, use the canvas extent for the “Output extent” (click on the ... to see the extent options).



The default grid colouring is greyscale. To add colour to the grid, open the Layer Property > Style tab and select pseudocolour as the render type. If you can't see the desired colour ramp, scroll to the bottom of the colour ramp display box and select "New Colour Ramp", then Colour Ramp Type "cty-city". A large range of colour ramps can then be selected.



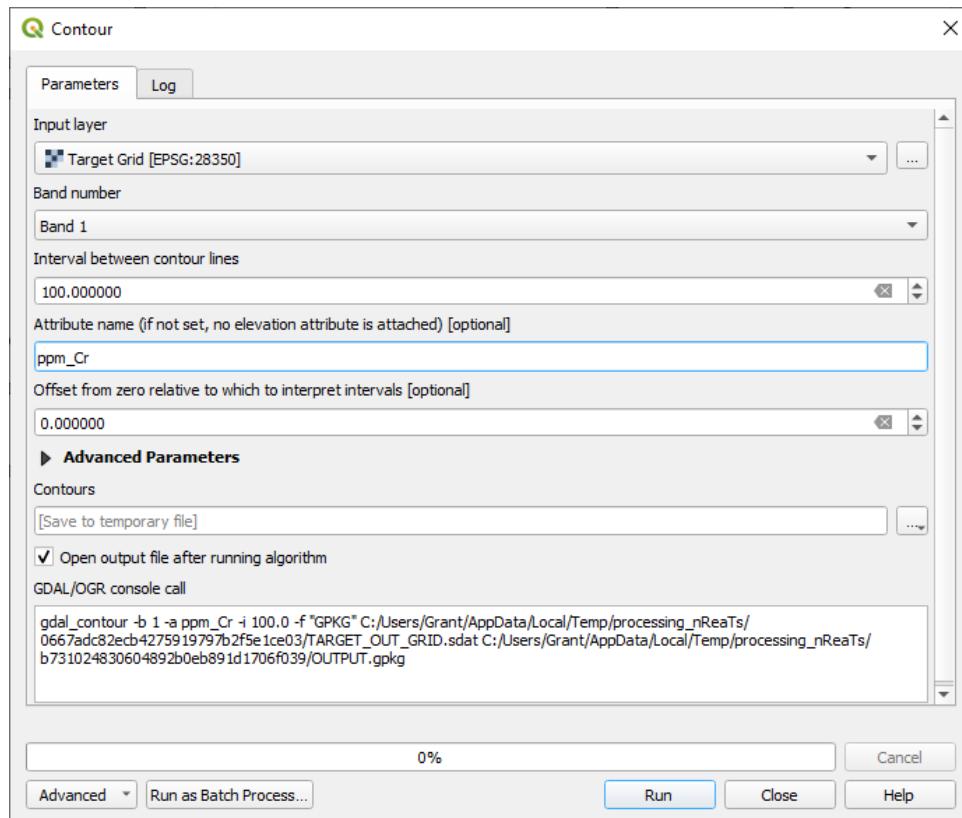
A common ramp to use is the QGIS > grass "bcyr" colour ramp. Save this as a standard gradient (lower left-hand tick box) and save "Save Color Ramp" with a suitable name (e.g. Default Colour Ramp).



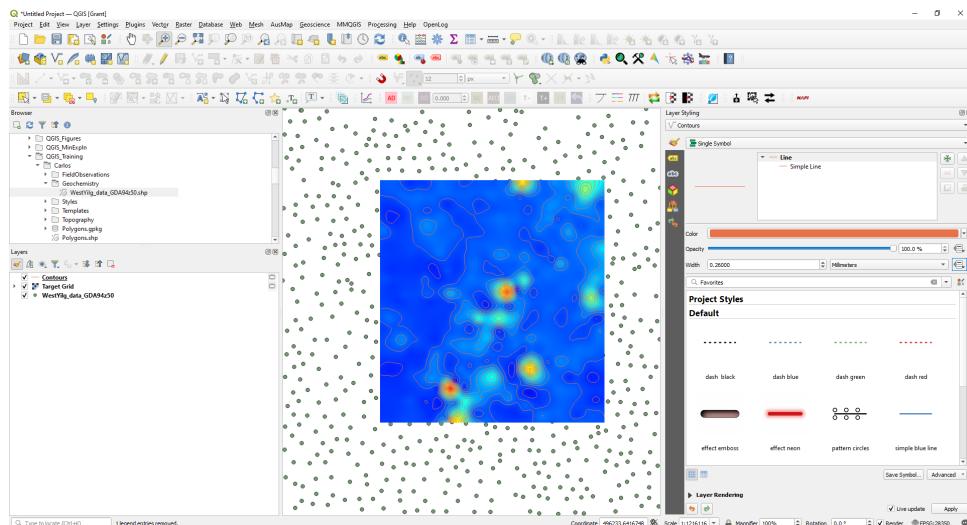
There are a variety of gridding option in QGIS (see menu item raster > interpolation) but I have found the SAGA gridding tools, which includes b-spline, inverse distance and kriging, to be the best for geochemical data. Note that the spline method will not be exact and will overshoot and undershoot some of the point values. Check a few different methods to find one that suits you best.

## 8.3 Contouring Surface Geochemical Data

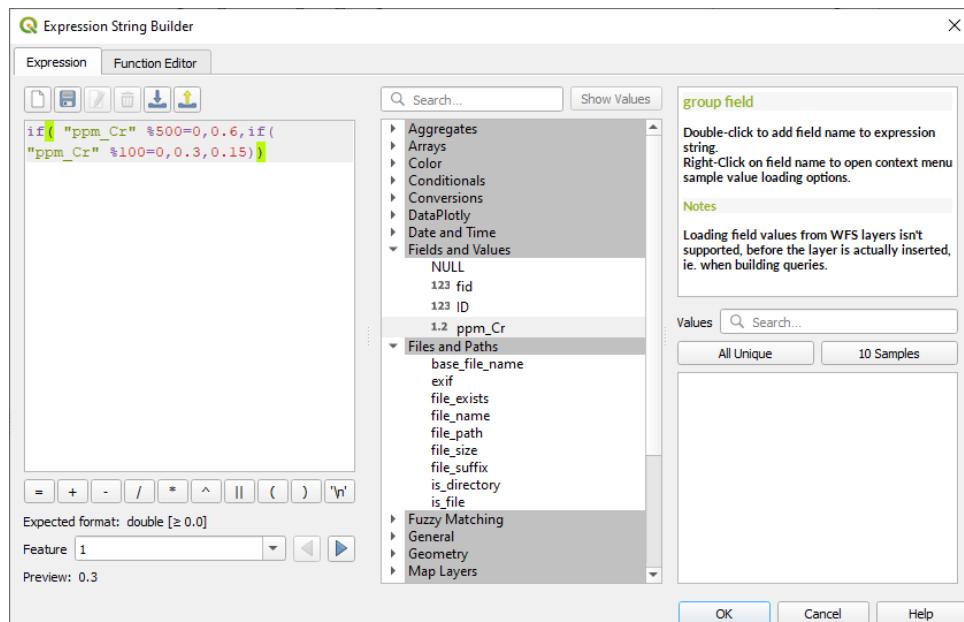
To create contours of the data, use the Raster > Extraction > Contour menu item.



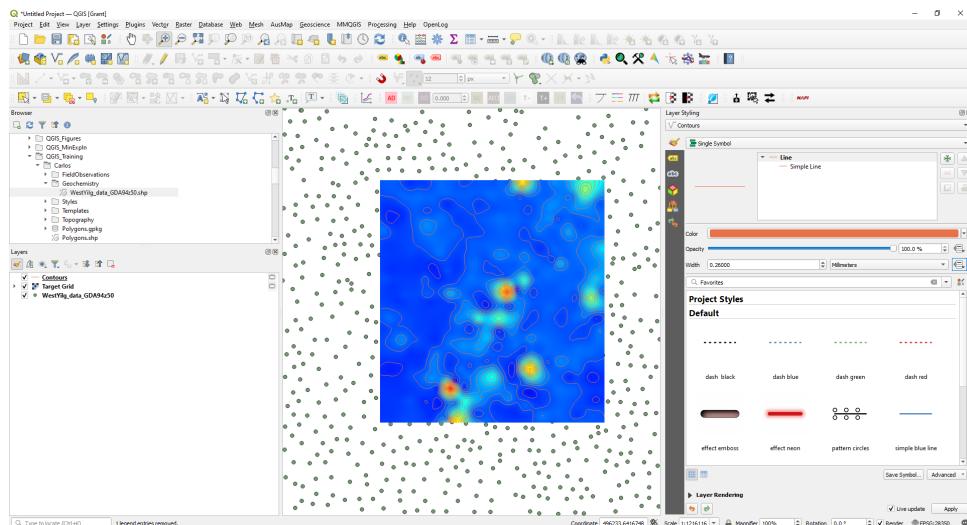
In this example I have used a contour interval of 100 ppm and called the contour field name “ppm\_Cr”. This can be saved as a temporary file to check the results before saving a final version.



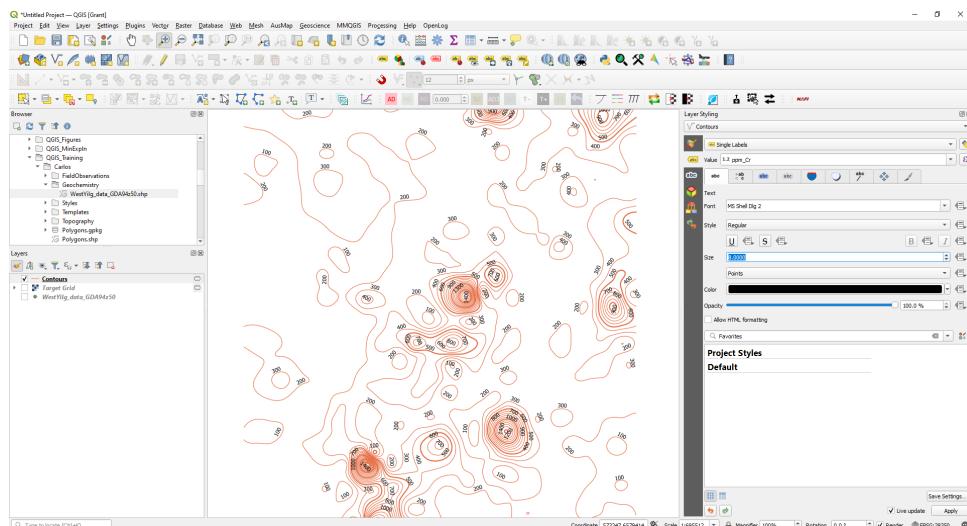
To emphasise significant value contours, like every 500 ppm for example, use the Data Driven Override box to the right of the “Width” option in the Layer Styling panel. Open the edit option to bring up the Expression String Builder.



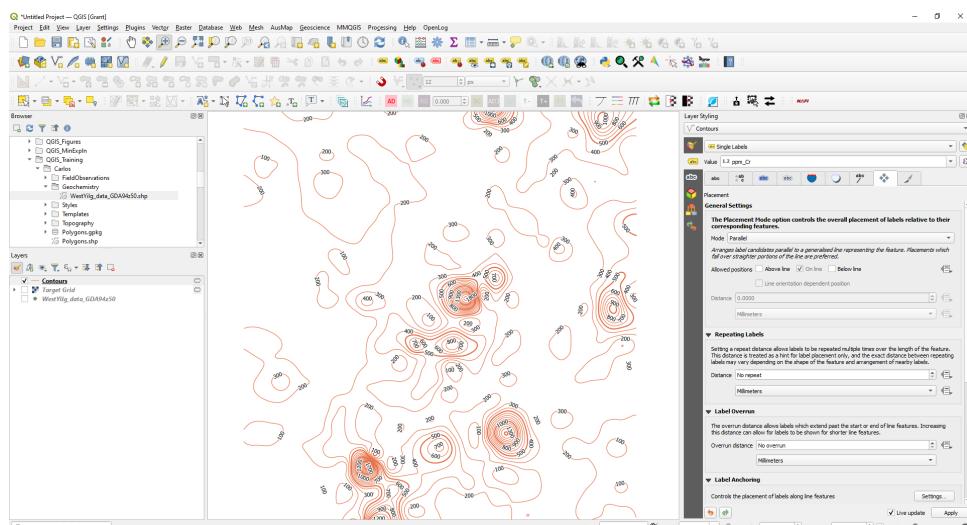
The code is saying if the contour value (ppm\_Cr) is divisible by 500 with a zero remainder, i.e. is a multiple of 500, then use a line thickness of 0.6 mm. The % symbol returns the remainder after a division. If the number is not a multiple of 500, then test if it is a multiple of 100. If it is, then use a line thickness of 0.3, otherwise use a line thickness of 0.15.



We can now annotate the contour lines using the Layer Styling panel and select the Label tab and choose the Single Labels option and the ppm\_Cr field for the value to be plotted.



The default view is shown above. To tidy this up change the font size (on the first tab “abc”) to 8, choose a white buffer of 0.8 (third tab along) and the placement (on the 8th tab, four directional arrow), set to Mode Parallel, tick on “On Line, uncheck the “Above Line” setting.



This looks a lot better and can be fine-tuned depending on your data.

### 8.3. Contouring Surface Geochemical Data

# CHAPTER 9

## GEOPHYSICAL DATA IMPORT AND DISPLAY

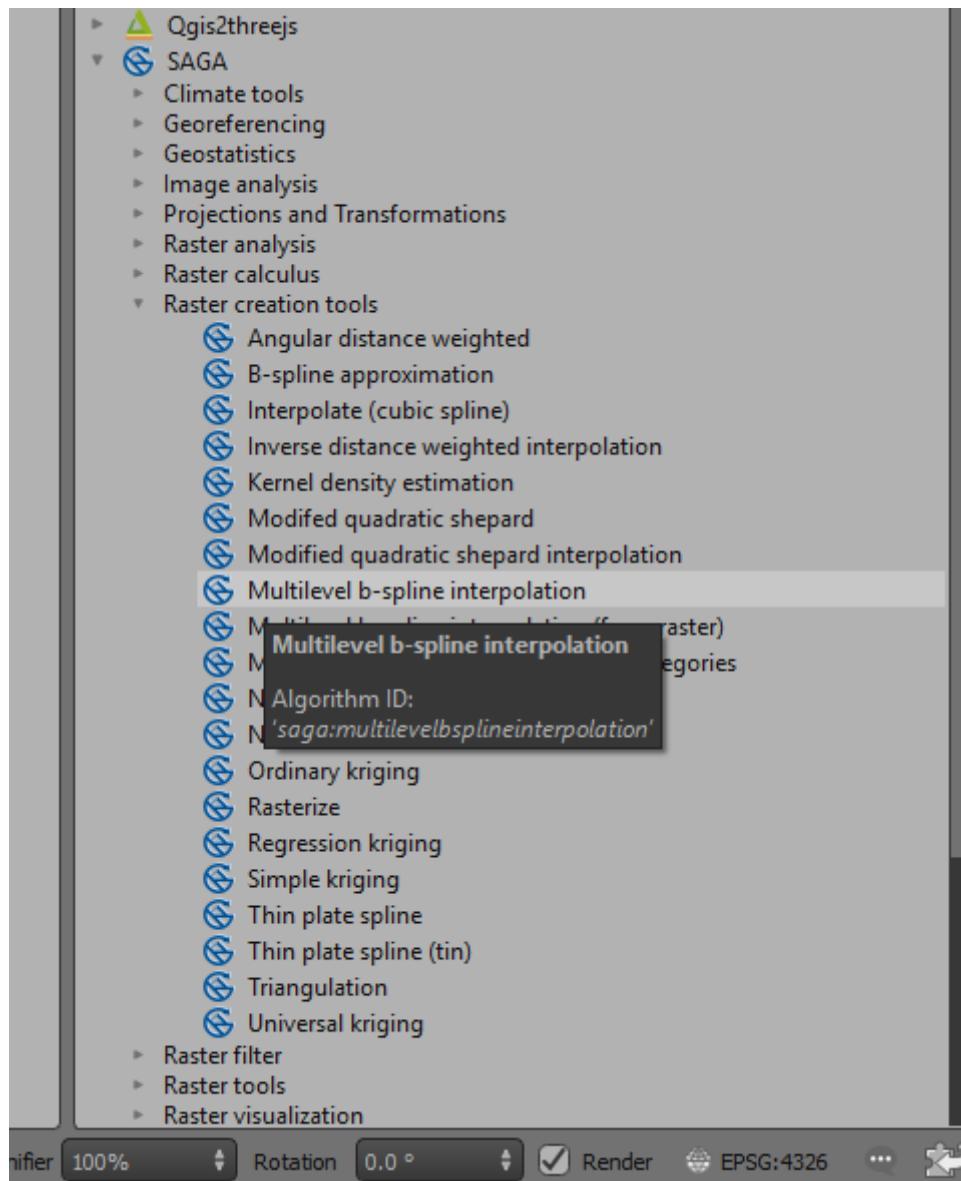
### 9.1 Data Import

Geophysical data usually comes as located data files (text) or grid files. QGIS can read many grid formats with \*.ers, and \*.tif (geotiff) files the most common, and these can be loaded by dragging the file name from the Browser Panel into the map window. Note that Geosoft \*.grd files require conversion to \*.ers files via their free viewer Oasis Montaj program (available from [www.geosoft.com](http://www.geosoft.com)). Note that some raster image files have to be opened via the Data Source manager > Raster options, e.g., BIL files.

When opening located data text files, remember that shapefiles can only have field names up to 10 characters in length. If your text files have longer field names, then it is suggested you use a free text editor like [Notepad++](#) or [ATOM](#), for large files) to modify the field names.

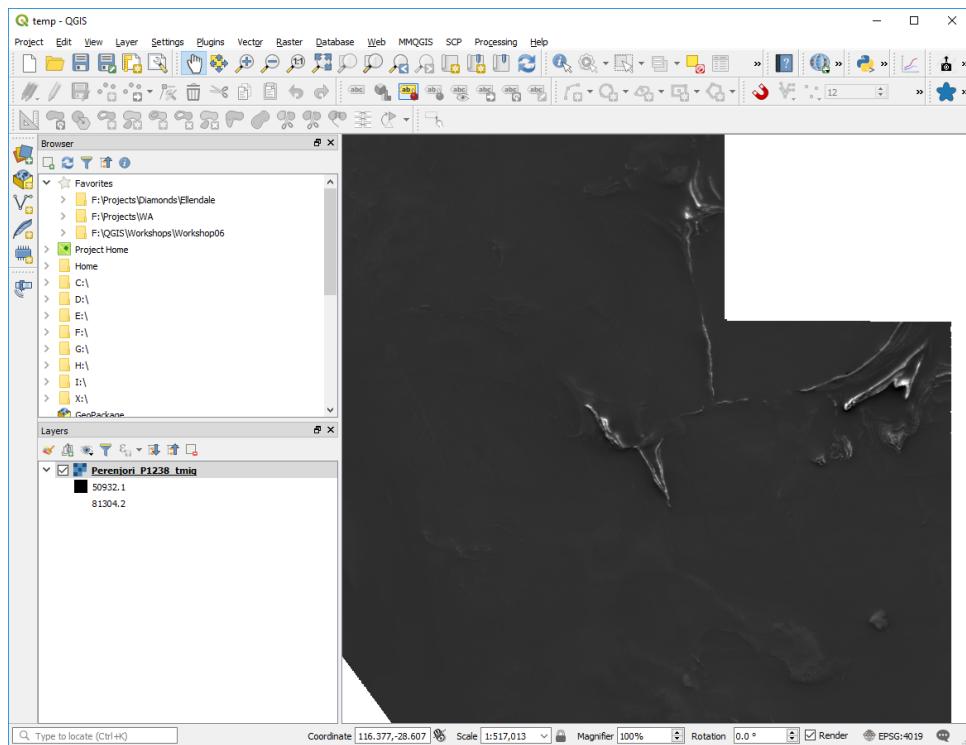
Alternatively, after you have imported the located data, you can save it as a GeoPackage file which does not have the 10-character field length restriction.

There are numerous methods to create grids of located data. I typically remove the tie lines by using a filter based on the Line number before I create the grid. One method I have found useful is to use the SAGA > Raster creation tools and use the “Multilevel b-spline interpolation” option.



Grid files are treated as raster files and are usually displayed as greyscale by default. To change the display, open the layer properties dialog and select “Style”. A variety of options are available including changing the colour ramps, colour stretch and display value limits. For a coloured image, use the Render Type > “Singleband Pseudocolour” option.

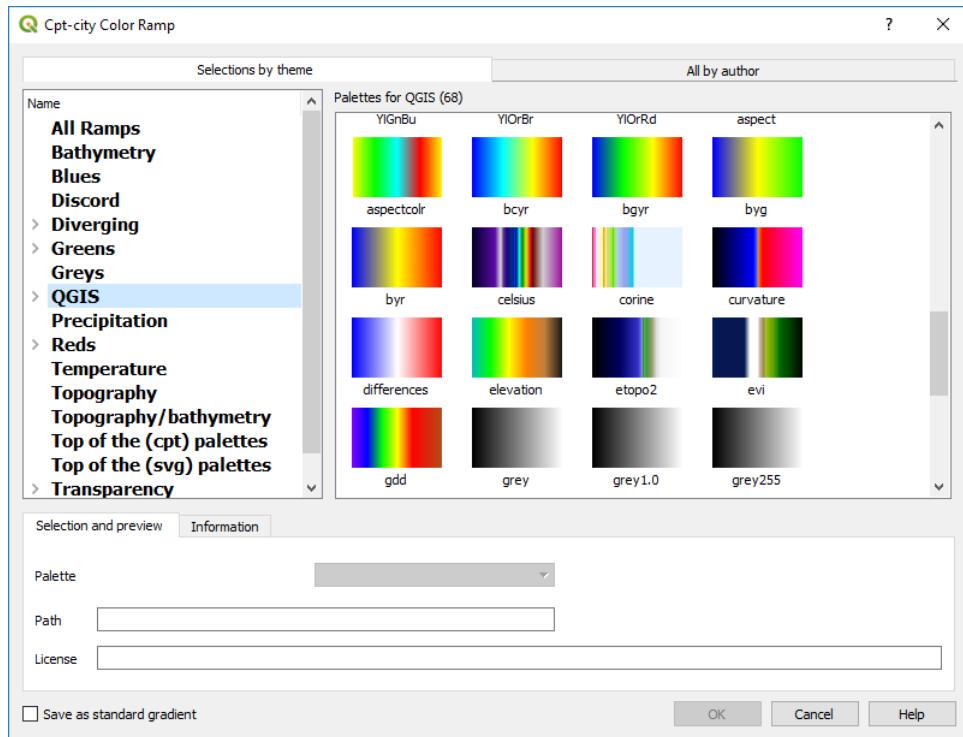
You may also want to create a polygon file as an outline of the area to be gridded. This can then be used to clip the grid to the data.



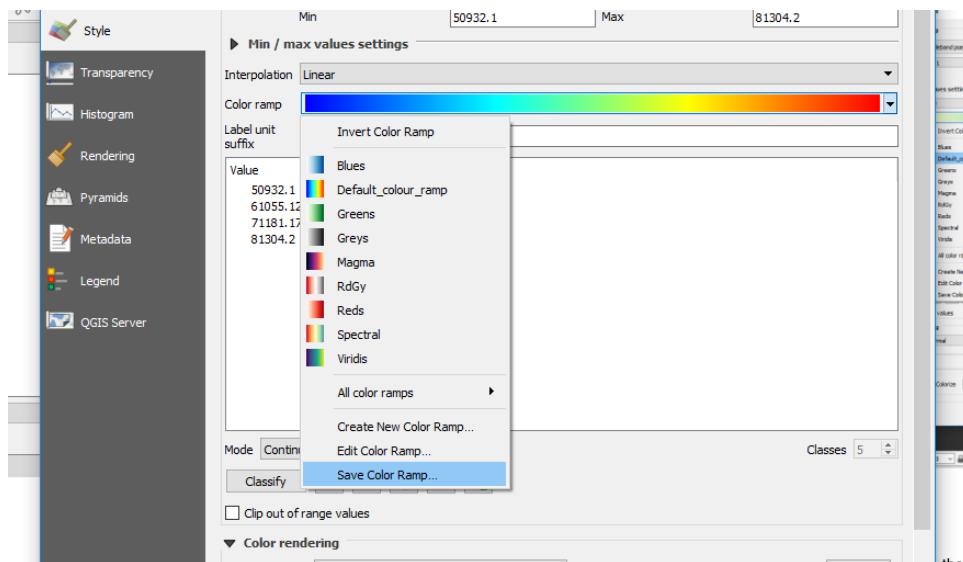
## 9.2 Colour Ramps

Additional colour ramps are available by clicking on the down arrow to the right of the “Color ramp” dialog box and selecting “Create New Color Ramp...”, select “Catalog: cpt-cty” from the drop-down box to display a variety of available colour ramps.

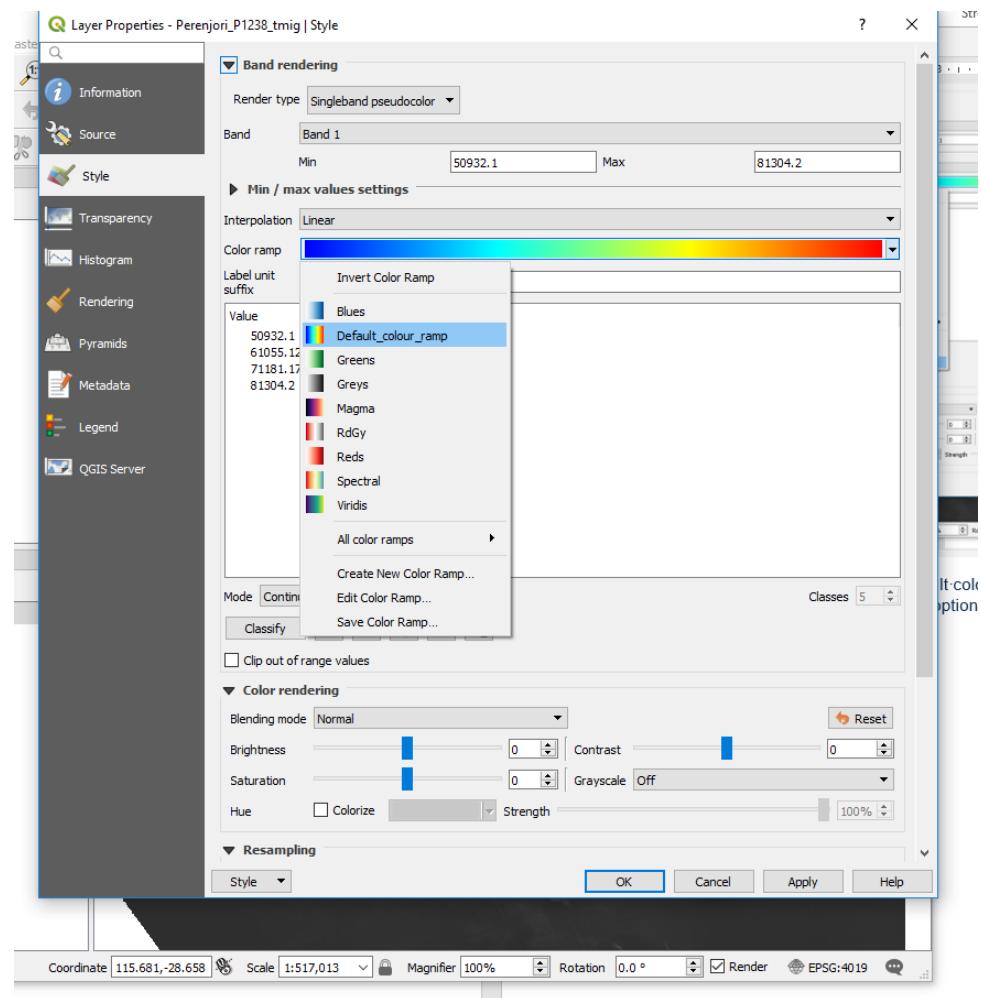
Colour ramps have also been developed by the Centre for Exploration Targeting (CET) in Perth that have better colour perception. These can be reviewed and downloaded from [here](#). Download the QGIS xml file and import via the Options > Style manager dialog box. My preference is to use the CET-R1 to CET-R3 ramps which are rainbow style colour ramps and they have the blue to magenta colour ranges which work well for shading magnetic images for example.



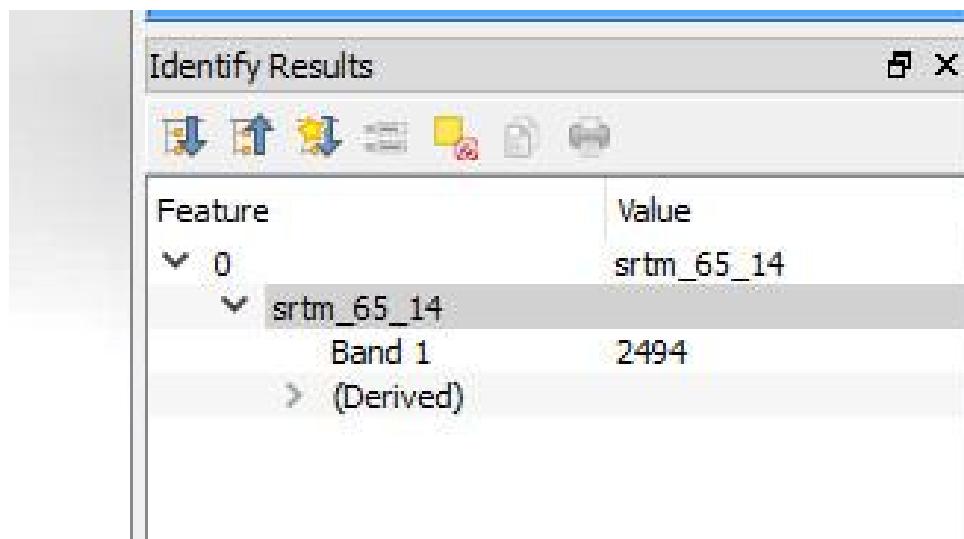
The “bcyr” is also good option for colouring geophysical data grids. Select the “Save as standard gradient” tick box in the lower left of the dialog box, then the Save Color Ramp.



Save the color ramp with a name, e.g. default colour ramp, and “Add to favorites” so it shows up on your quick colour ramp select options.

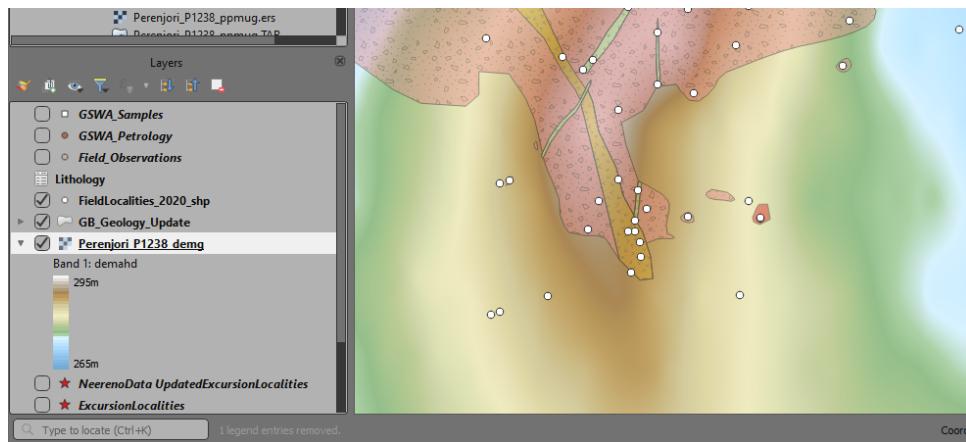


Note that you can use the information icon to examine the values of a pixel or grid location. If the value is not displayed in the Identify panel, try minimising the left-hand side column, as sometimes the column width is too wide for the panel to display the cell value on the right-hand side.

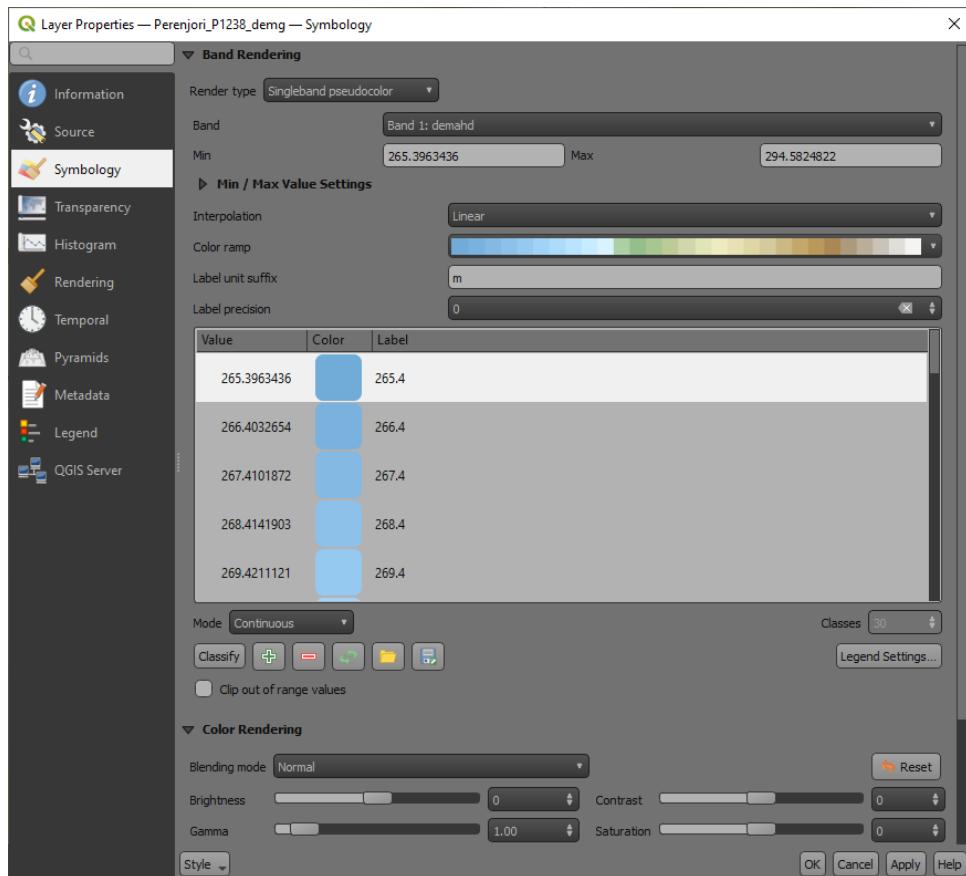


If you open a grid file and have difficulties displaying the data, e.g. with 1VD magnetic images, zoom in to a small area of the grid and then “Stretch to Current Extent” (available as a right click on the layer name in the Layers panel) to stretch the data to something visible.

When a continuous raster layer is added to the map window, the layer panel displays the colour range.



The display of the data labels in the Layers panel and the legend can be controlled using the “Legend Settings” options in the lower right-hand side of the Symbology tab.



New in version 3.18 is to have a continuous colour bar in the Layers panel and the legend for print layouts.

In the Layer Properties > Symbology tab, select the “Legend Settings” button to change the way the colour stretch is displayed and the size and orientation of the colour bar for your print layout.

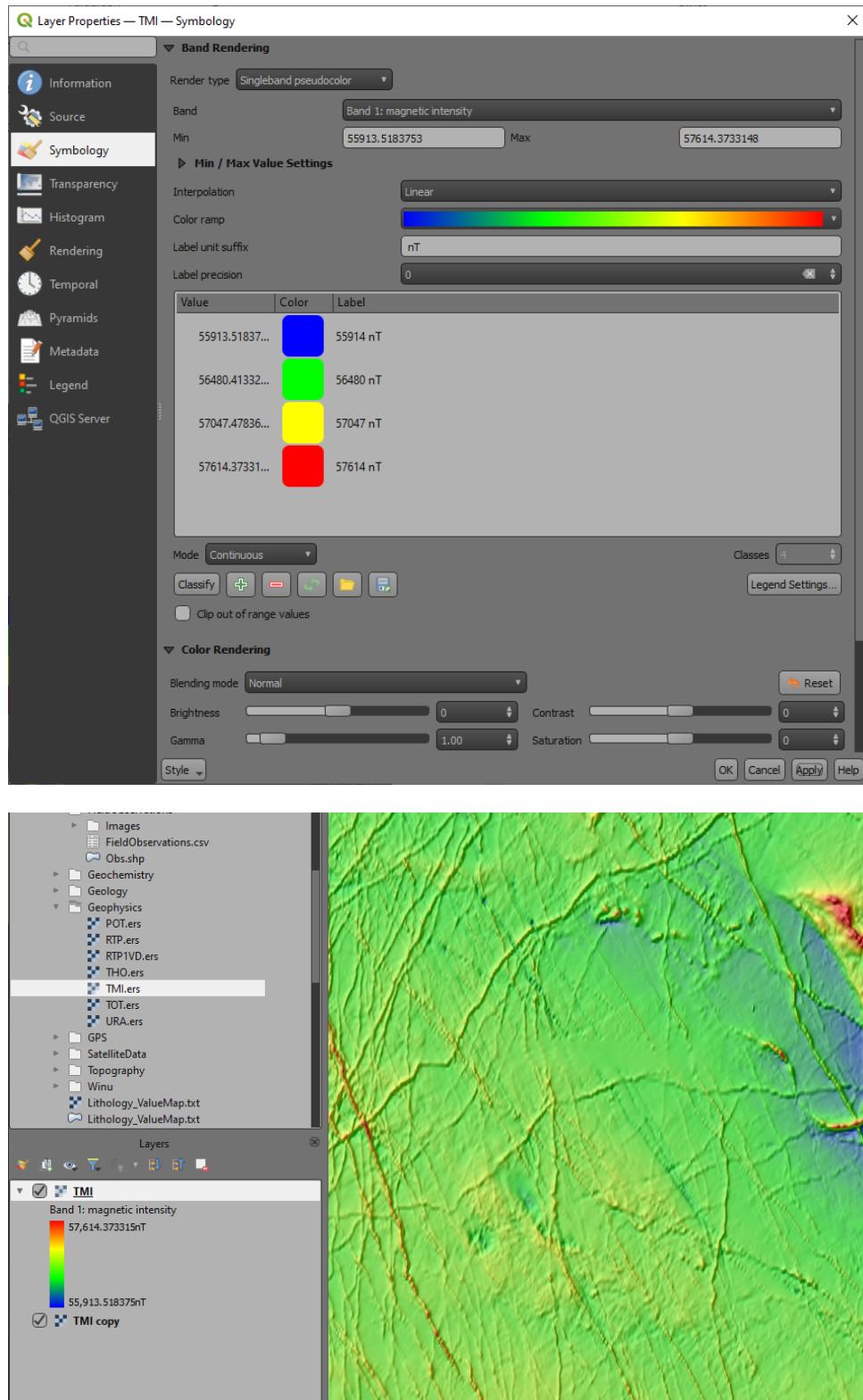


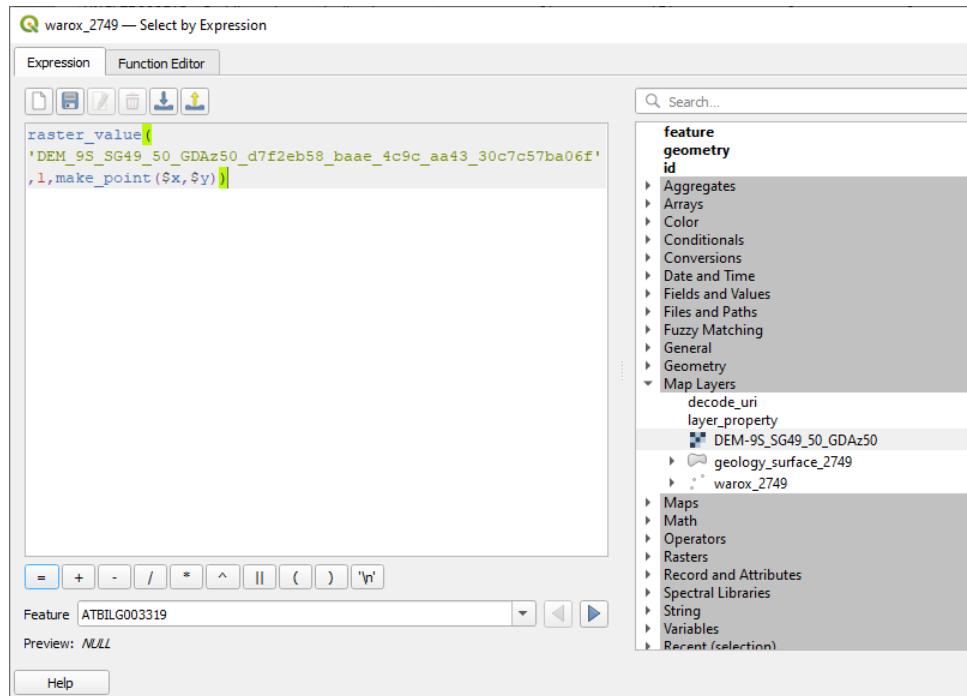
Fig. 1: Example of continuous colour bar in the Layers panel.

## 9.3 Extracting Point Data from a GRID

If you need to extract a value from a grid (raster) file e.g., drill hole collar elevations from a DEM, there are at least two options.

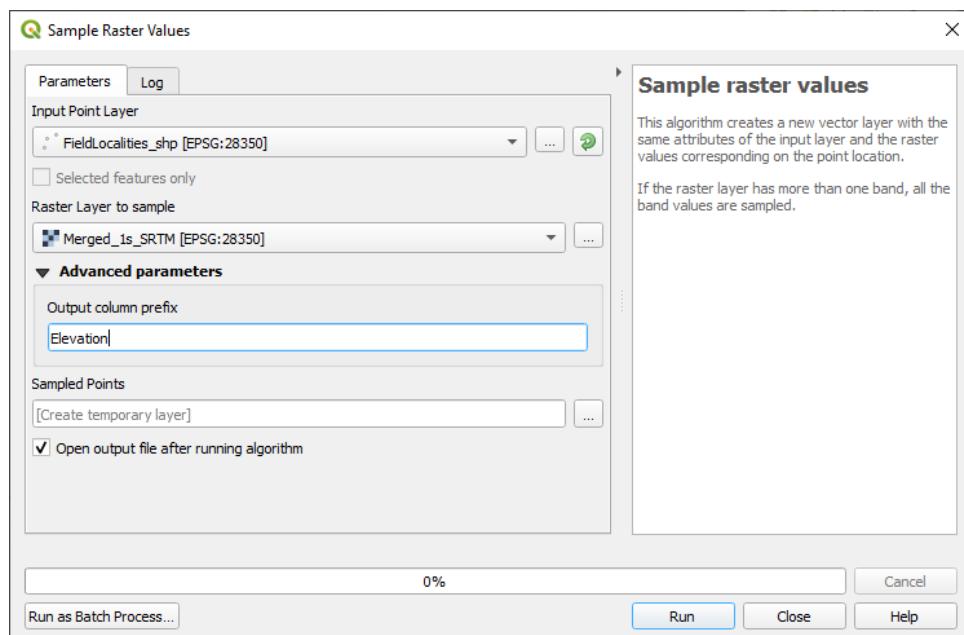
The first option is to use an expression in the layer expression editor dialog to populate the desired field (for example using the create new field in the attribute table) as follows;

`Raster_value('dem layer',band,make_point($x,$y))` This expression looks at the dem layer or grid name, the band in the grid with the data to be extracted, and creates a point.



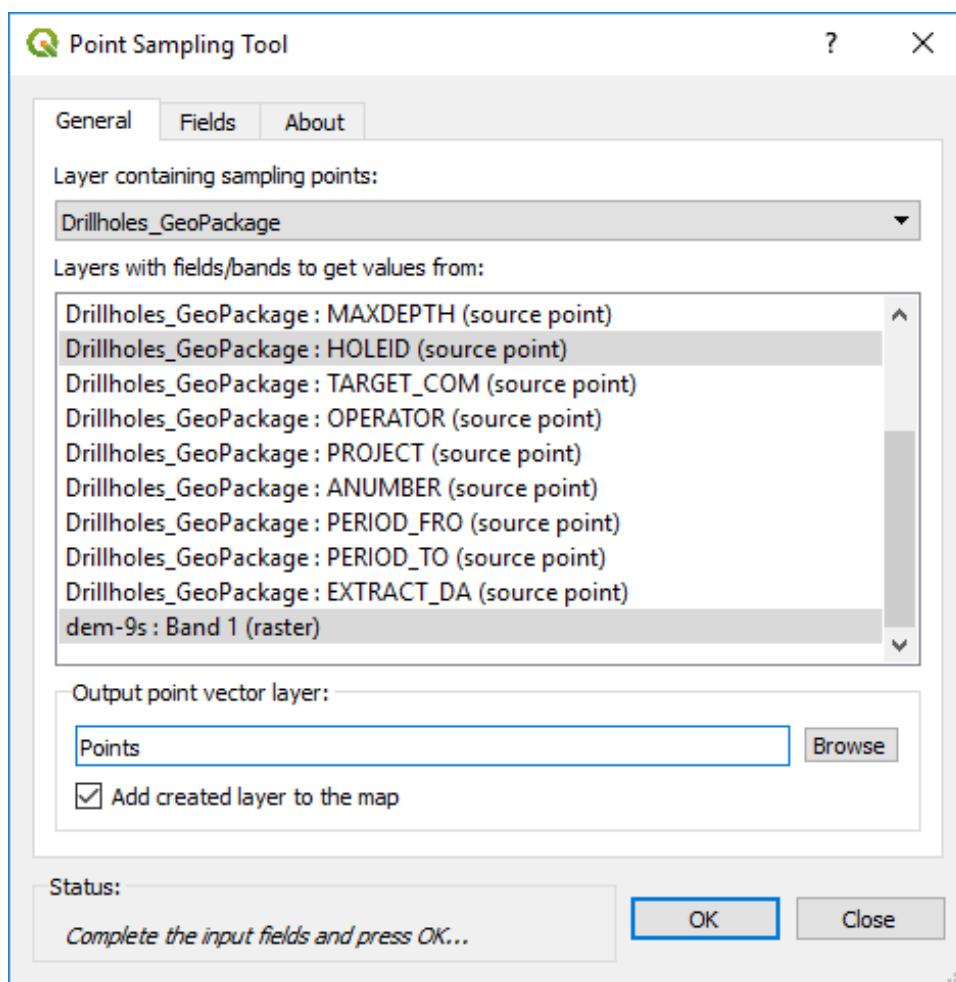
The other method is to use the “Sample Raster Values” algorithm or the “Point Sampling Tool” plug-in.

To find point values in a raster grid, use the Processing Toolbox > Raster Analysis > Sample Raster Values algorithm. This creates a new layer which can then be used to overwrite the original layer with the new values.



The Point Sampling plug-in tool can also be used to sample points in a grid, e.g. drill hole collar elevations using

a digital elevation grid. The output creates a separate file with the resulting values. The point and grid layers need to be in the same projection. The tool is found under the Plugin > Analysis > Point Sampling Tool.

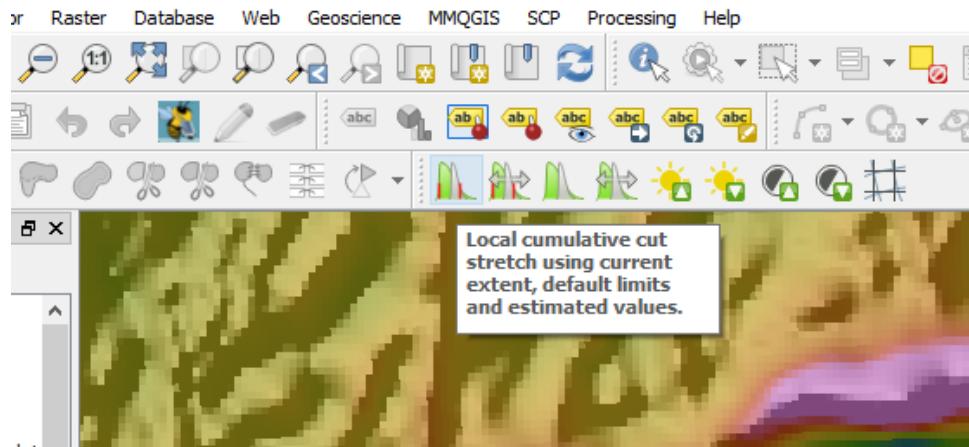


Select the layer containing the points to be used for the data extraction (drill holes), then select the fields to be exported with the points (Hole number), and then select the layer with the elevation data (e.g. dem-9s:Band 1). This will then create a file with hole number and elevation. This will then need to be joined to the drill collar file for example. I find it quicker to use the v.what.rast algorithm above, as this automatically updates the data field.

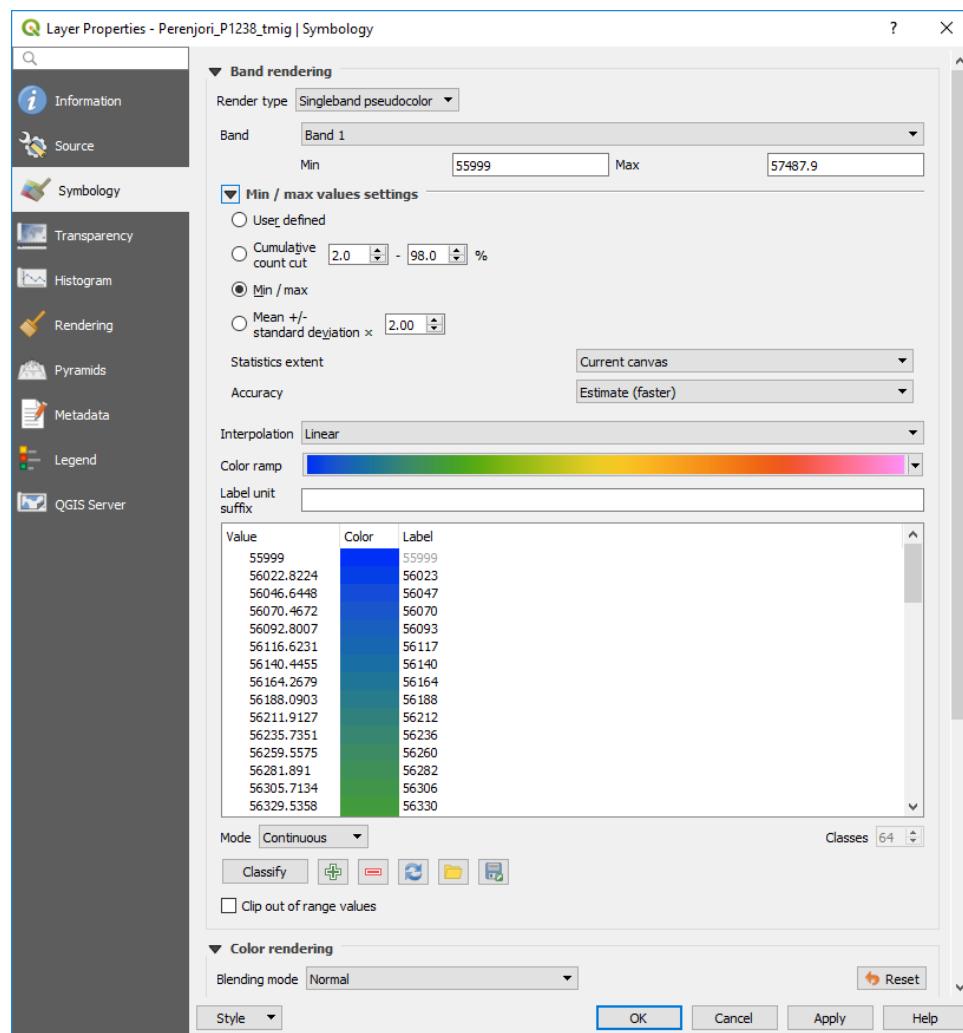
## 9.4 Custom Data Stretch

The Raster toolbar has a collection of basic display options to change how the image is displayed.

Images can be stretched to the entire image or window extent. See the mouse over for how these icons work.



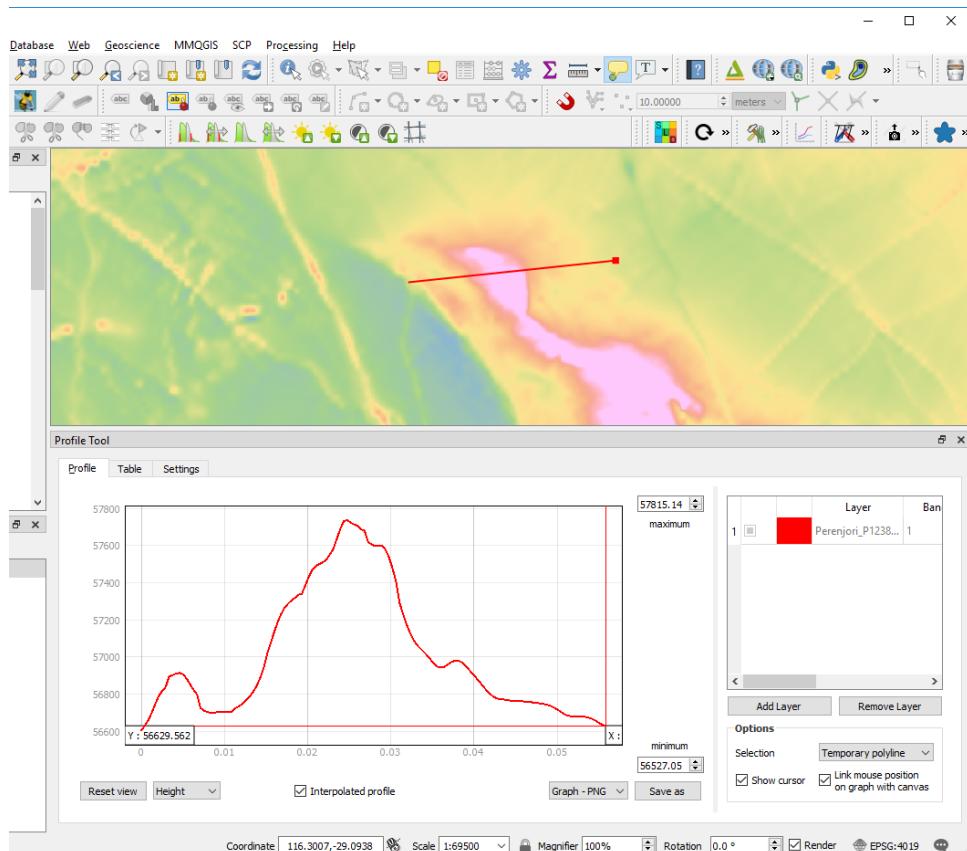
Display settings can also be selected in the Symbology tab of the Layer Properties.



## 9.5 Profiling Gridded Data

To obtain a profile across any gridded data, use the “Profile” plugin. Open the Profile plugin (usually on the menu bar) and use the “Add Layer” button to add the layer from where you want the values extracted. Draw a line using one click to start and a double click to complete the line.

The resulting profile values can be copied to the clipboard (under the Table tab) for use in programs like Excel.



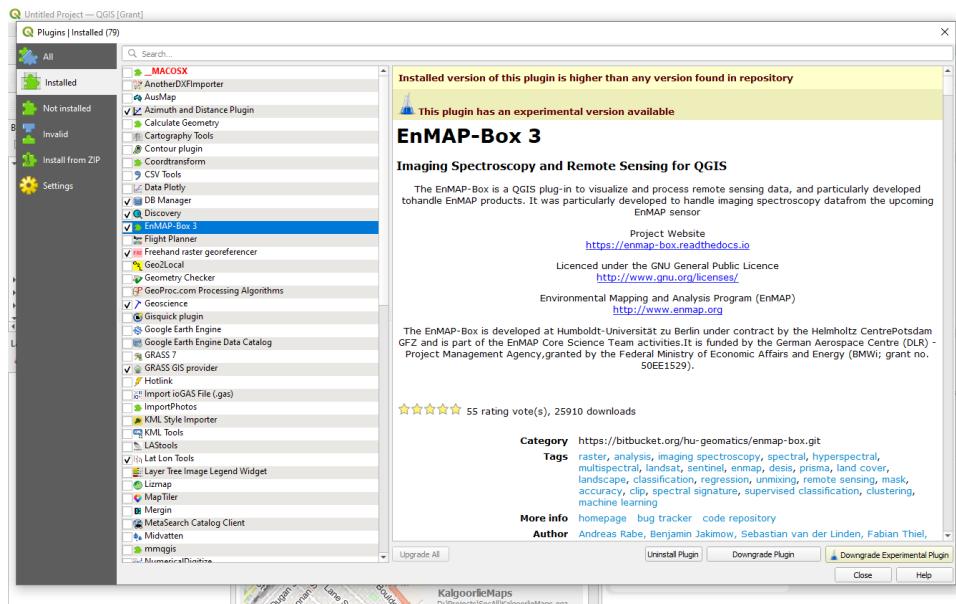
## 9.6 Creating Stacked Profiles and Colour Bars

Creating “stacked profiles” of data, especially magnetic data is important for the identification of small discrete features in wide spaced aeromagnetic data. One example is in the search for kimberlite pipes in regional (>300 m) spaced line data.

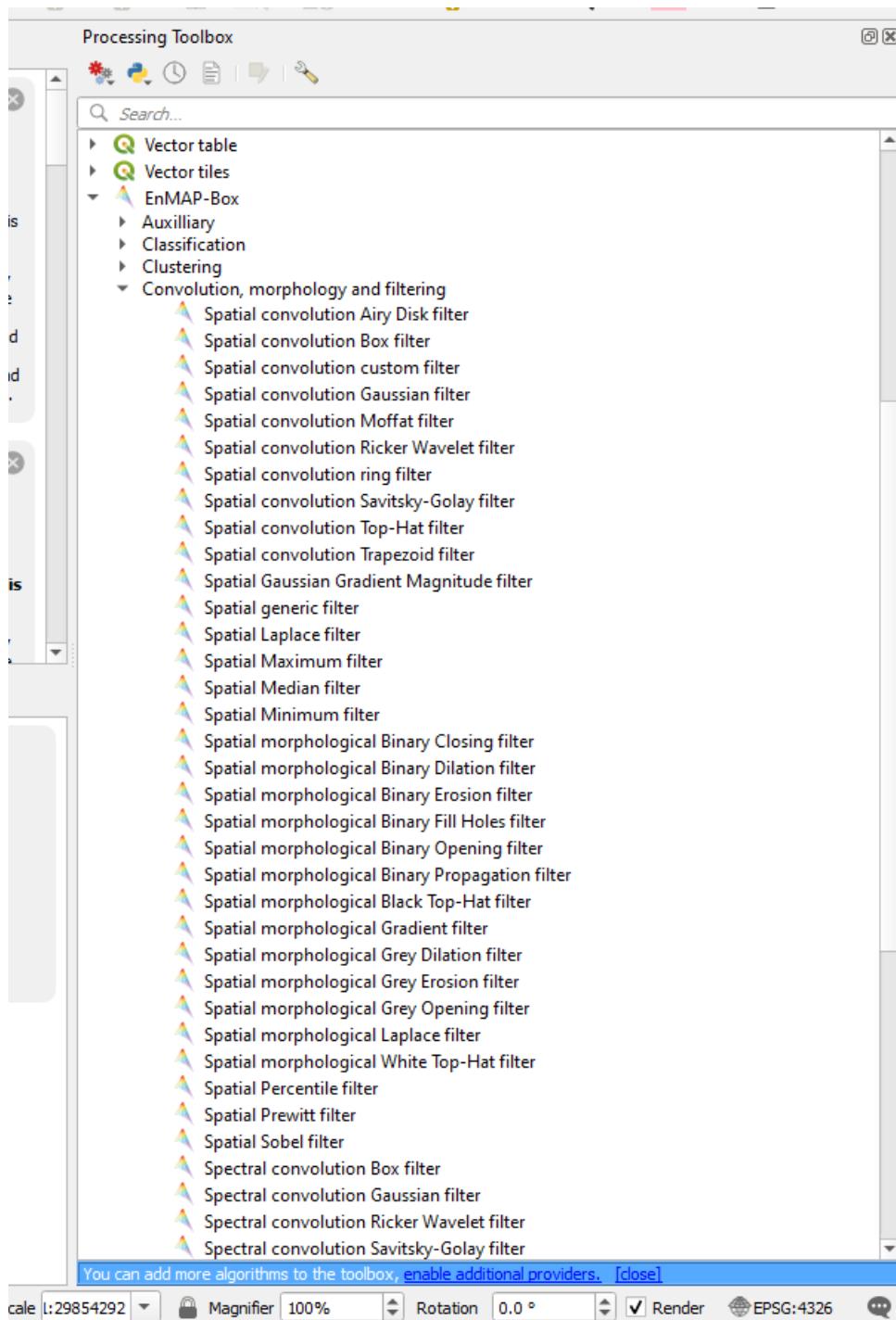
This algorithm has been created by Benoit at [GeoProcessing](#) in South Africa and is part of their “GeoProc” toolset. The stacked profile tool allows the user to import located line data to plot stacked profiles of the data. It is important that the located data is in “point” format not multi-point data format.

## 9.7 First and Second Vertical Derivatives

First vertical derivative images can be created using the EnMap Box plugin and can be downloaded from [this link](#). This plugin has been designed to cater for a new satellite that was launched in 2022 and has a large variety of tools for remote sensing data including filtering.



When the plugin is installed it puts an additional link in the Processing Toolbox.



The Spatial Prewitt filter creates a first vertical derivative (1vd) image, the Spatial Laplace filter creates a second vertical derivative (2vd) image and the Spatial Gaussian Gradient Magnitude filter creates a type of analytical signal image.

Clipping of the resultant images may be required and set the background with no data to zero or -99999 so it can be set to transparent.

Note also when creating images for use in MapInfo, create ERMapper ers grid files.

# CHAPTER 10

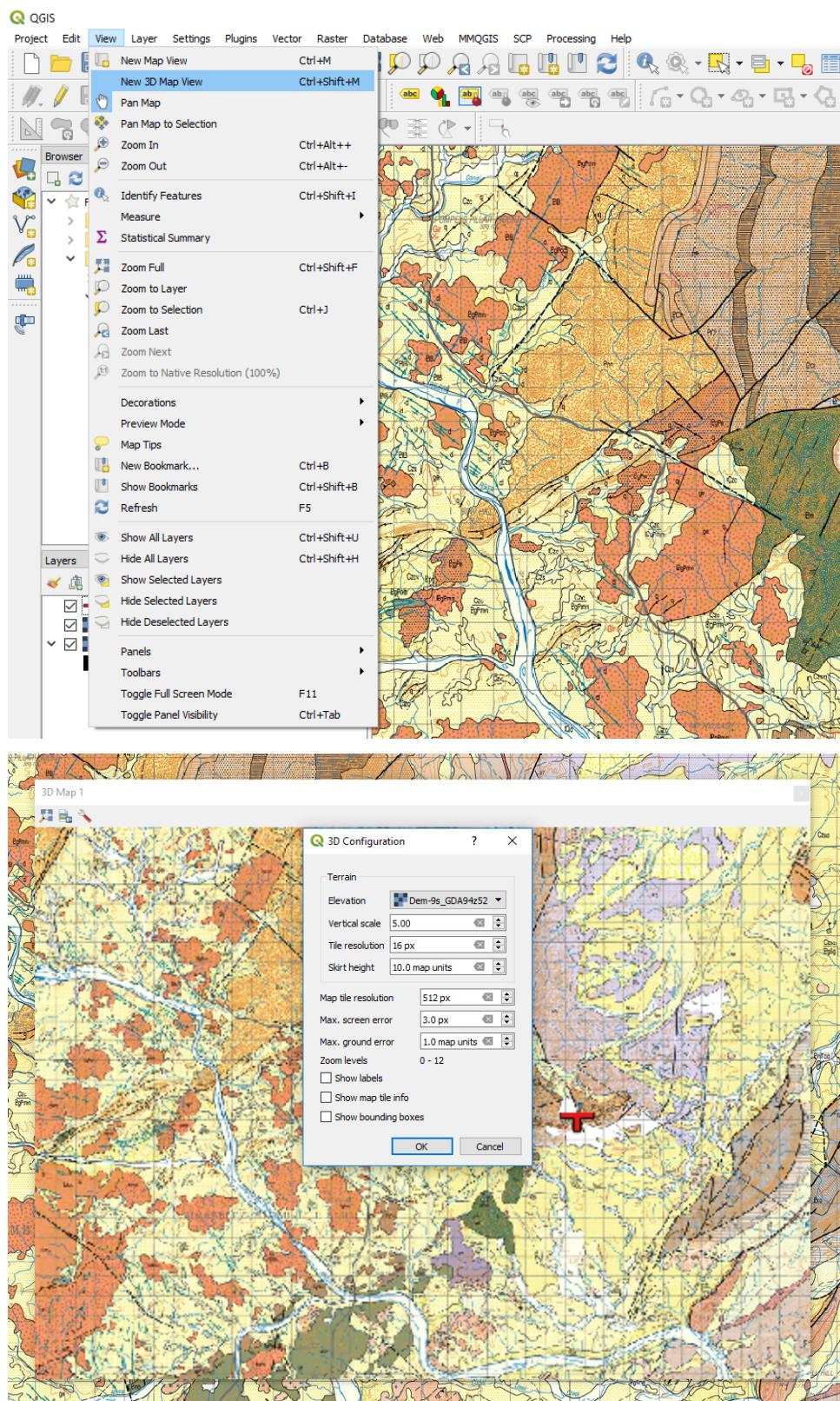
## 3D IMAGE DISPLAY

QGIS v3 now has a 3D view capability built in as a standard part of the program (3d Map View) or by using the QGIS2threejs plugin. The QGIS2threejs is the best option at this time for viewing geological data in 3D. Downhole drill hole traces can be displayed if the 3D coordinates have been calculated.

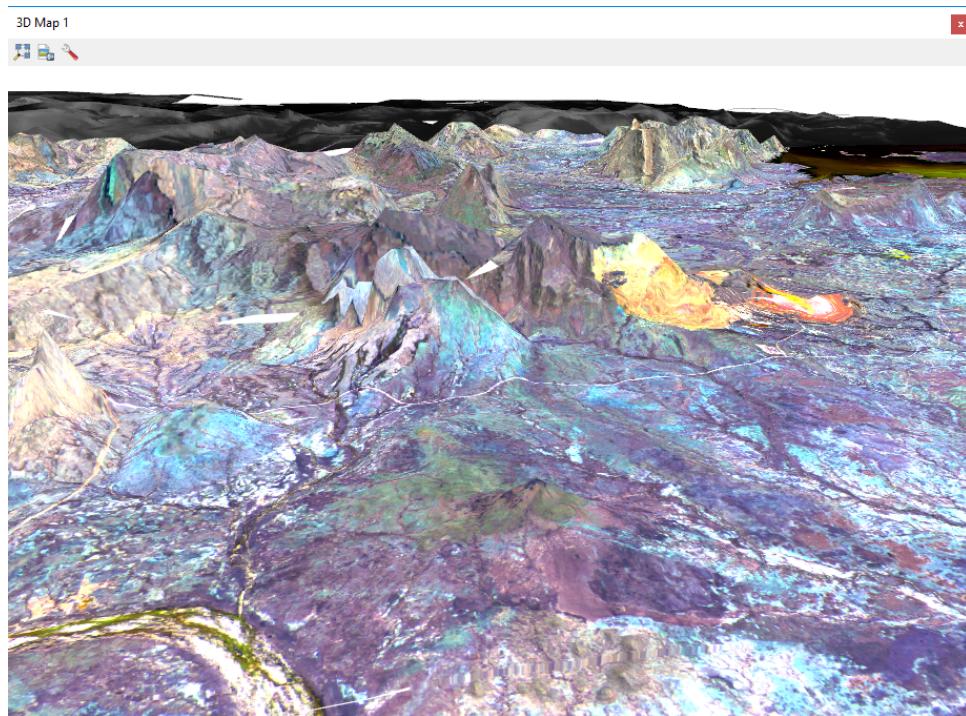
### 10.1 3D Map View

The layers require to be projected, i.e. not a geographic projection, lat/long, and they should all be in the same projection.

To run the 3D view, place the layers into the map window with the DEM layer at the bottom of the layer stack. Go to the View > New 3D Map View menu item and create a 3D map window. Resize the window to suit and select the little spanner symbol to open-up the options dialog.



Select the layer to be used as the “Elevation”, set the vertical exaggeration and press OK. Use the hand icon to move the display in the window. To tilt the display to see the 3D effect, hold the shift key and drag the mouse towards down. With the shift key depressed you can also rotate the image. Scroll speed will be dependant upon the size of your grid files and the speed of your PC.

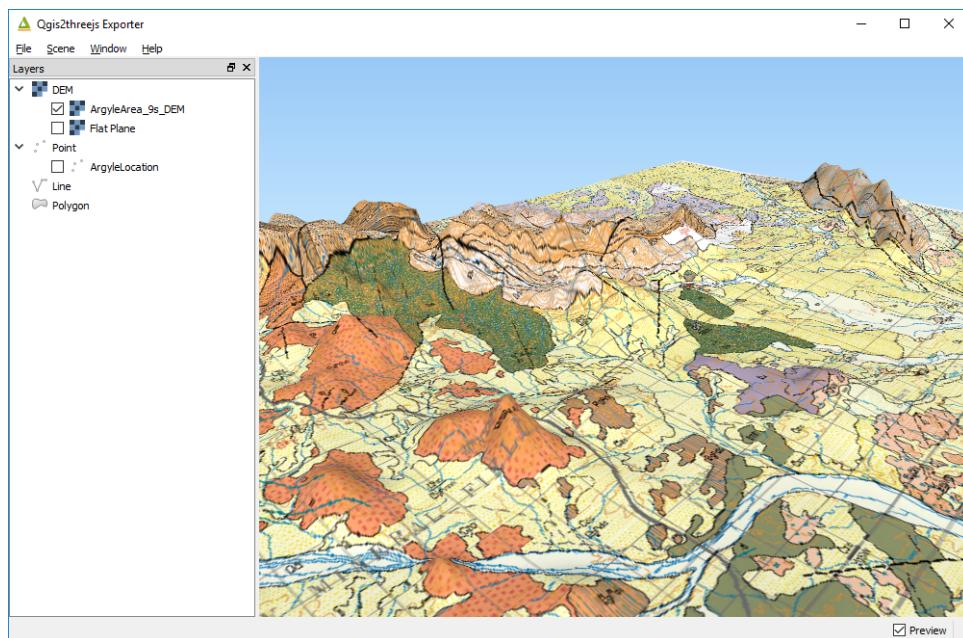


Any image displayed in the map window can be used for 3D display.

## 10.2 QGIS2Threejs Plugin

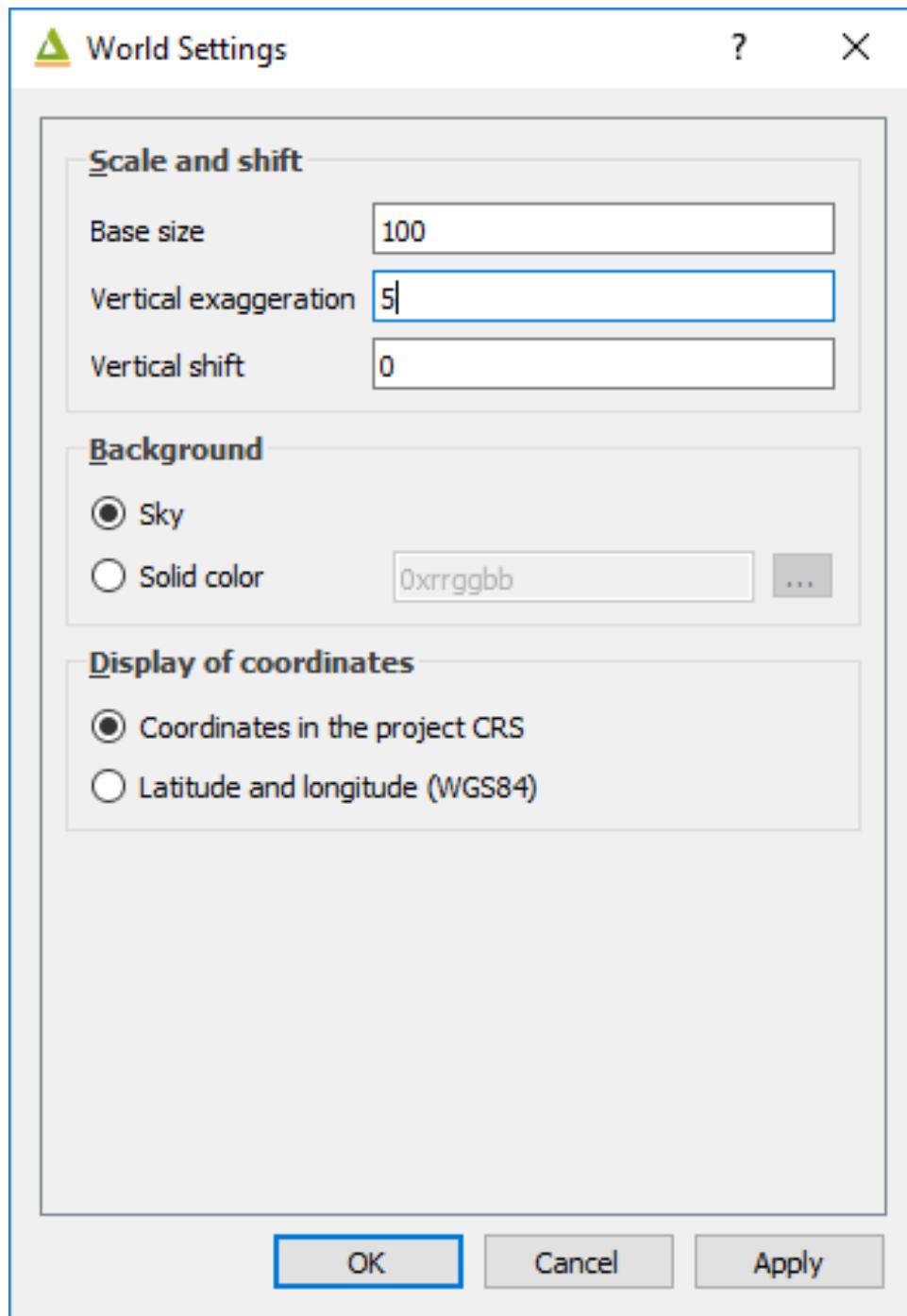
This plugin is more flexible than the 3D map view at the present stage of its development for geological application. The layers require to be projected, i.e. not a geographic lat/long projection, and they should all be in the same projection. If you have data in 3D, i.e. with x, y and z coordinates, then this plugin can display the data. If you get weird effects, you may have a lat/long layer in the map window which may be causing problems. Close any lat/long layers and re-run the plugin.

To use this plugin, load a DEM or any type of grid file over which you would like to drape data. For example you may wish to drape a satellite image or geological map over a digital terrain model.

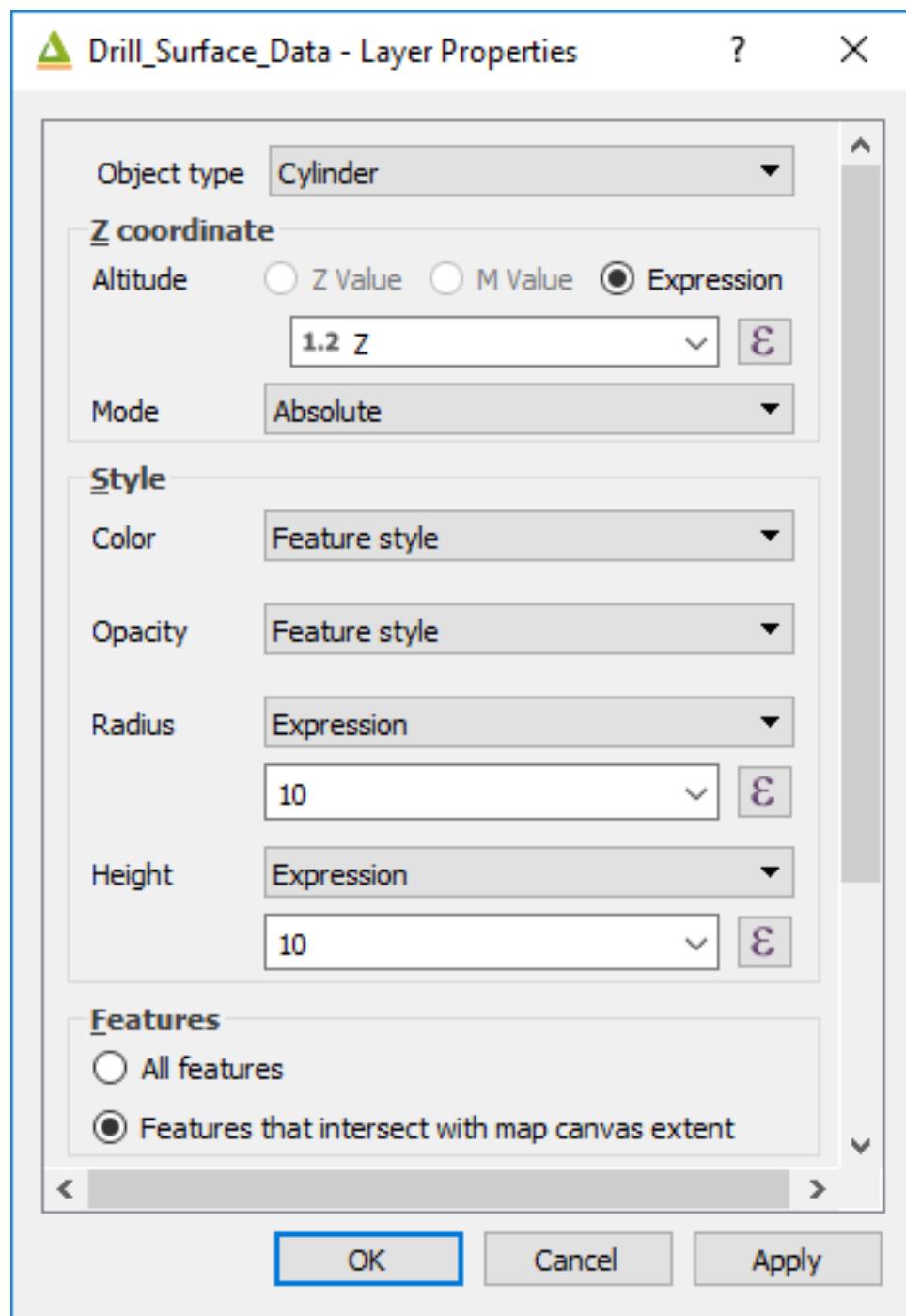


Make sure the grid is on the bottom, with the layers to be draped on top of the DEM/grid layer. Run the QGIS2Threejs plugin and select the DEM layer.

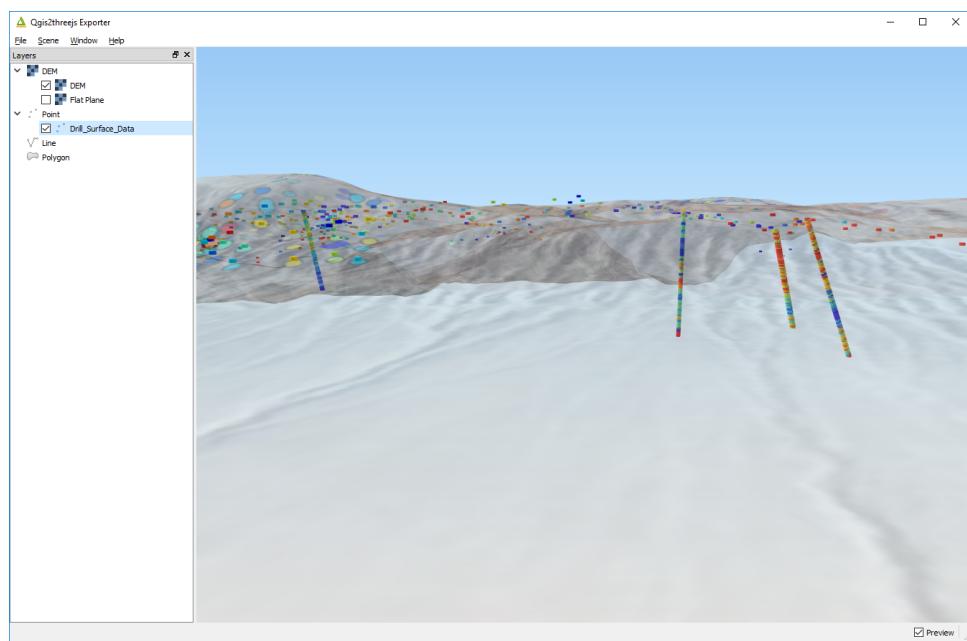
Vertical exaggeration can be changed using the Scene > World Settings dialog box.



If you have vector data with a z (e.g. RL or elevation data) then right click on the vector layer name in the QGIS2Threejs window and select the z value to use in the “Z Coordinate” options. Downhole drill hole data can be plotted using this method.



The image below shows a Google Earth image, draped over a SRTM digital terrain model, with a vector file of surface samples and drill hole sampling.



# CHAPTER 11

## REMOTE SENSING

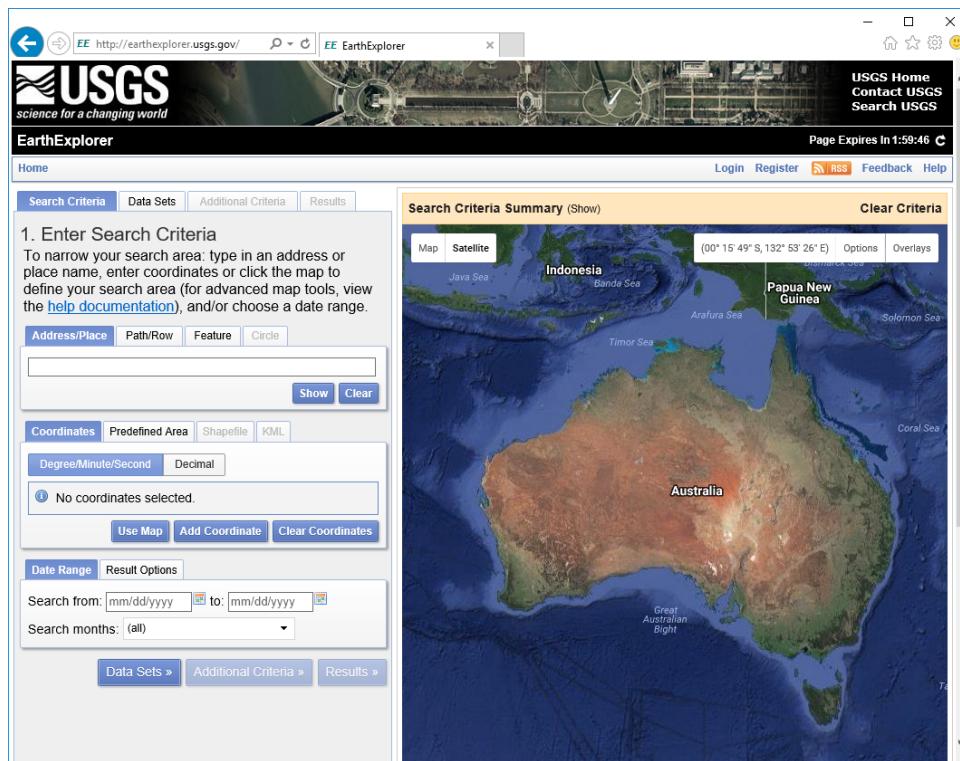
The availability of free satellite and other remote sensing data has created unique opportunities for the display of this data to assist geological interpretation and analysis. QGIS can display the normal satellite images, but it also has a powerful plugin, the Semi-Automatic Classification (SCP) plug-in, which can be used to source, select, download and process satellite imagery. [Video tutorials are available on the web](#) and cover a variety of remote sensing applications including land cover classification.

To download ASTER and Landsat data, you are required to register (free) at the USGS EarthExplorer portal. These registration details will be required to be entered on the SCP download/login window. Sentinel data download requires (free) registration at the ESA Sentinel data access portal. Note that it might take three or four days for your registration at ESA to become active. Recently, the search times on the ESA site via the SCP plugin have been very slow and it has been my experience lately that the USGS EarthExplorer portal is the fastest way to select and download ASTER data.

### 11.1 United States Geological Survey (USGS)

The USGS hold an enormous amount of free data, most of which is accessible via its EarthExplorer portal. To download the data, you are required to register (free) and select a username and password.

ASTER and Landsat data are two of the remote sensing datasets available from the USGS. These datasets are also easily accessed via the Semi-Automatic Classification plug-in in QGIS (see Section 11.1). Digital elevation, radar and Lidar data are also available from the USGS. Note that Sentinel 2 data is now no longer available from the EarthExplorer portal.



Use the Register button to create a free account or log in if you have an existing EarthExplorer account. Logging in allows you to download datasets.

Enter the search criteria by using a Landsat path/row identifier, or by using the map or by a coordinate. Once you have selected an area, choose the data set you are seeking, add “Additional Criteria” if you want to filter your search, e.g. by date range.

← ⏪ ⏹ https://earthexplorer.usgs.gov

## EarthExplorer Manage Criteria

Search Criteria Data Sets Additional Criteria Results

### 2. Select Your Data Set(s)

Check the boxes for the data set(s) you want to search. When done selecting data set(s), click the *Additional Criteria* or *Results* buttons below. Click the plus sign next to the category name to show a list of data sets.

Use Data Set Prefilter ([What's This?](#))

Data Set Search:

This data set list is cached for performance. If your user permissions have changed or you are not seeing an expected dataset, [click here to refresh your list](#).

- + Aerial Imagery
- + AVHRR
- + CEOS Legacy
- + Commercial Satellites
- + Declassified Data
- + Digital Elevation
- + Digital Line Graphs
- + Digital Maps
- + EO-1
- + Global Fiducials
- + HCMM
- + ISERV
- + Land Cover
- + Landsat 
- + LCMAP
- + NASA LPDAAC Collections
- + Radar
- + UAS
- + Vegetation Monitoring
- + ISRO Resourcesat

[Clear All Selected](#) [Additional Criteria »](#) [Results »](#)

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The provided map shows a satellite view of a rural area with fields and roads. A specific location is marked with a blue dot and labeled "Rapid".

Each of the data categories have a range of datasets available. The image below shows an example of searching for ASTER data.

**4. Search Results**

If you selected more than one data set to search, use the dropdown to see the search results for each specific data set.

**Show Result Controls**

**Data Set** [Click here to export your results](#)

ASTER Level 1T V3

« First < Previous 1 of 8 Next > Last »	
Displaying 1 - 10 of 76	
	<b>Local Granule ID:</b> AST_L1T_00303192008014732_20150523101338_17247 <b>Coordinates:</b> -16.5092, 127.5082 <b>Acquisition Date:</b> 2008/03/19 <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a>
	<b>Local Granule ID:</b> AST_L1T_00303192008014724_20150523101338_17253 <b>Coordinates:</b> -15.9753, 127.6308 <b>Acquisition Date:</b> 2008/03/19 <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a>
	<b>Local Granule ID:</b> AST_L1T_00301012008013539_20150522132339_91757 <b>Coordinates:</b> -16.9761, 130.025 <b>Acquisition Date:</b> 2008/01/01 <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a>
	<b>Local Granule ID:</b> AST_L1T_00301012008013531_20150522132335_10613 <b>Coordinates:</b> -16.4423, 130.1485 <b>Acquisition Date:</b> 2008/01/01 <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a> <a href="#"></a>

[View Item Basket](#) [Submit Standing Request](#)

**Search Criteria Summary**

The provided maps are no

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[U.S. Department of the Interior](#) | [DOI Inspector General](#) | [White House](#) | [E-gov](#) | [No Fear Act](#) | [FOIA](#)

If there is data available from your search request, you can then examine the thumbnails of the scenes and select which dataset is the best one for your purposes. The footprint icon will show the area covered by the scene and notepad and pencil icon brings up a better view of the data including its metadata. Click on the download icon to download the data. The format of the data will depend on the data type and this needs to be researched by the user.

## 11.2 European Space Agency (ESA)

ESA has launched a number of satellites recently in their Sentinel series to observe the land and ocean areas for climate and monitoring purposes (see [this site](#)). For geological work, the author has found the Sentinel 2 data is most useful. The Sentinel 2 mission monitors variability in land surface conditions, and its wide swath width and high revisit time (5 days) will support monitoring of changes to vegetation within the growing season. The coverage limits are from between latitudes 56° south and 84° north (ESA).

Currently the best way to select and download the Sentinel data is via the [ESA Copernicus Open Data portal](#). Register for a free login and password at the portal.

The following description is taken from the [ESA Sentinel website](#).

Table 1: Sentinel-2 products available for users are listed in table below.

Name	High-level Description	Production & Distribution	Data Volume
Level-1C	Top-of-atmosphere reflectances in cartographic geometry	Systematic generation and on-line distribution	600 MB (each 100x100 km2)
Level-2A	Bottom-of-atmosphere reflectance in cartographic geometry	Systematic generation and on-line distribution and generation on user side (using Sentinel-2 Toolbox)	800 MB (each 100x100 km2)

*"L1C Products are a compilation of elementary granules of fixed size, within a single orbit. A granule is the minimum indivisible partition of a product (containing all possible spectral bands).*

*For Level-1C and Level-2A, the granules, also called tiles, are 100x100km2 ortho-images in UTM/WGS84 projection. The UTM (Universal Transverse Mercator) system divides the Earth's surface into 60 zones. Each UTM zone has a vertical width of 6° of longitude and horizontal width of 8° of latitude. (see Figure 1). Tiles are approximately 600 MB in size. Tiles can be fully or partially covered by image data. Partially covered tiles correspond to those at the edge of the swath.*

*The continuous acquisition of Sentinel-2 image data in a given MSI mode is called a "datatake". The maximum length of an imaging datatake is 15,000 km (e.g. continuous observation from northern Russia to southern Africa). All products contain granules/tiles from a single datatake. A datatake is presented inside a product as a set of one or more datastrips (corresponding to acquisition segments downlinked to different ground stations)."*

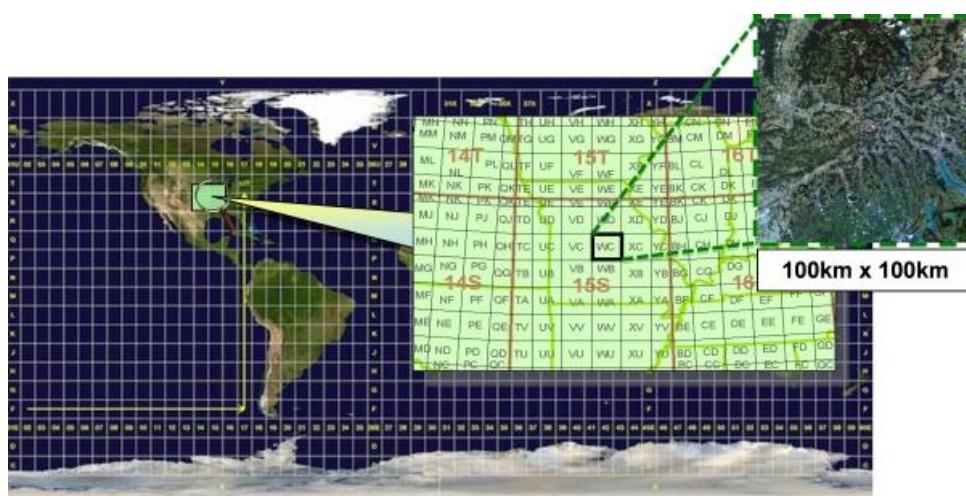


Fig. 1: Level-1C product tiling

The Sentinel 2 series A and B satellites are of relevance to geology as they have a high spatial resolution and 12 bands of spectral data. The multispectral imager (MSI) covers 13 spectral bands (443 nm-2190 nm) with a swath width of 290 km and spatial resolutions of 10 m (4 visible and near-infrared bands), 20 m (6 red-edge/shortwave-infrared bands) and 60 m (3 atmospheric correction bands). The Sentinel 2 satellites main

applications are in monitoring agriculture, forests, land-use change, land-cover change; mapping biophysical variables such as leaf chlorophyll content, leaf water content, leaf area index; monitoring coastal and inland waters; risk mapping and disaster mapping.

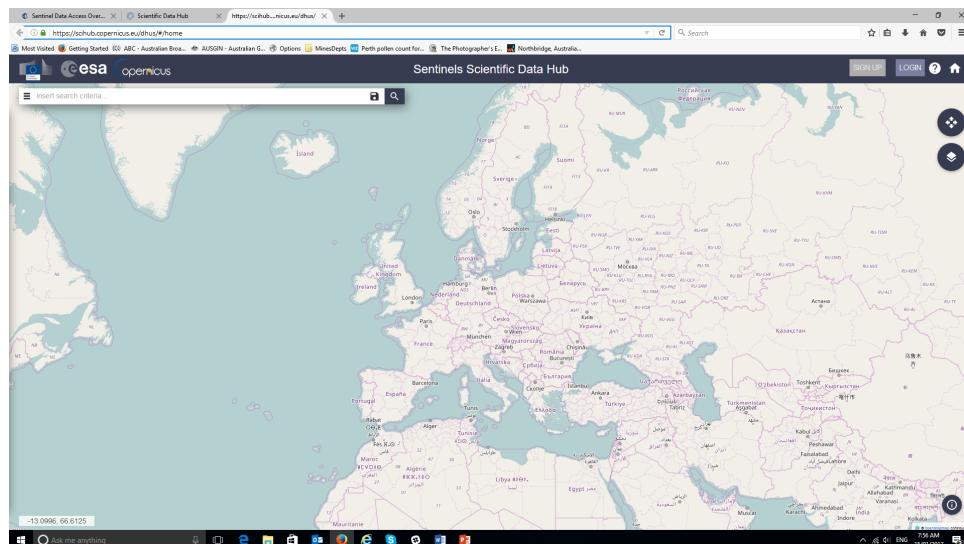
Table 2: Spectral bands for the SENTINEL-2 sensor

Band number	Central wavelength (nm)	Bandwidth (nm)	Spatial resolution (m)
1	443	20	60
2	490	65	10
3	560	35	10
4	665	30	10
5	705	15	20
6	740	15	20
7	783	20	20
8	842	115	10
8a	865	20	20
9	945	20	60
10	1380	30	60
11	1610	90	20
12	2190	180	20

The table below compares Sentinel 2 with other commonly used satellite sensors.

Common Name	Band Range (um)	Landsat 5	Landsat 7	Landsat 8	Sentinel 2	MODIS
Coastal	0.40 - 0.45			1	1	
Blue	0.45 - 0.5	1	1	2	2	3
Green	0.5 - 0.6	2	2	3	3	4
Red	0.6 - 0.7	3	3	4	4	1
Pan	0.5 - 0.7		8	8		
NIR	0.77 - 1.00	4	4	5	8	2
Cirrus	1.35 - 1.40			9	10	26
SWIR16	1.55 - 1.75	5	5	6	11	6
SWIR22	2.1 - 2.3	7	7	7	12	7
LWIR	10.5 - 12.5	6	6	10,11		31,32

The Sentinel data can also be accessed via the Sentinel portal after registration (Sign Up button), see [this link](#).



After logging on to the portal, scroll to your area of interest and highlight a rectangle for your data search. This

method of data selection is less intuitive than the USGS EarthExplorer data access and I would use a Sentinel 2 tile id to zoom to the area of interest.

A Sentinel tile index covering the world can be downloaded as a shapefile from the ESA website.

Sentinel 2 data can also be downloaded using the QGIS plug-in “Semi-Automatic Classification” which is discussed below.

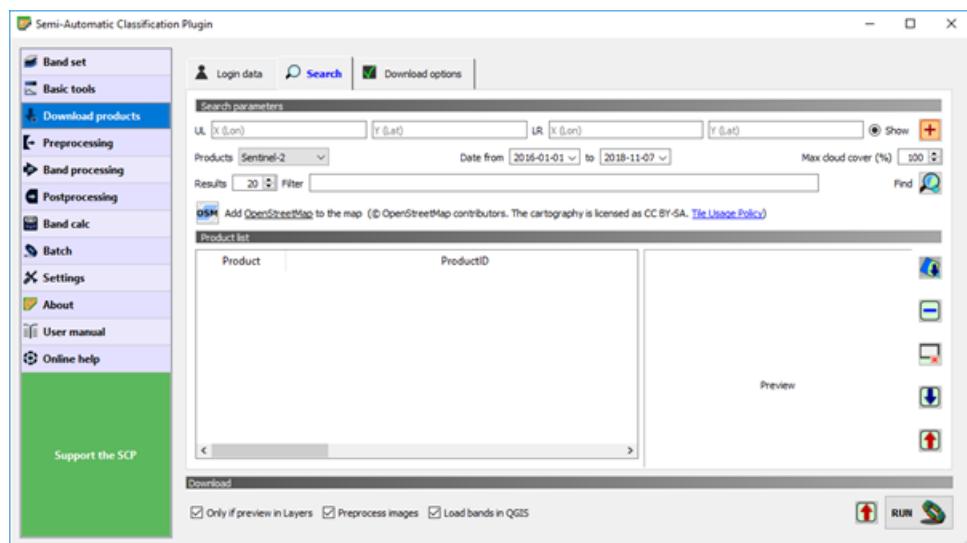
Note that radar data is now available from the Sentinel 1 mission.

## 11.3 Using the Semi Automatic Classification Plugin

Selection, downloading and processing of satellite remote sensing data can be achieved using the Semi Automatic Classification Plugin (SCP) written by *Luca Congedo* <<https://fromgistros.blogspot.com/p/semi-automatic-classification-plugin.html>>. After installing the plugin you can open the plugin via the main menu bar. Note the plugin automatically adds panels and toolbars which I normally close to free up window space.

Note that version 8 does not currently do atmospheric corrections on ASTER and Sentinel 2 data and if this is something required, then install version 7 - see FAQ on the SCP web site here <https://semiautomaticclassificationmanual.readthedocs.io/en/latest/>.

The following notes apply to the Semi-Automatic Classification plug-in version 7. Updates notes for version 8 to follow.



The main SCP window shows tabs for downloading data, as well as a variety of other pre and post processing options, band calculations and tools for land cover classification.

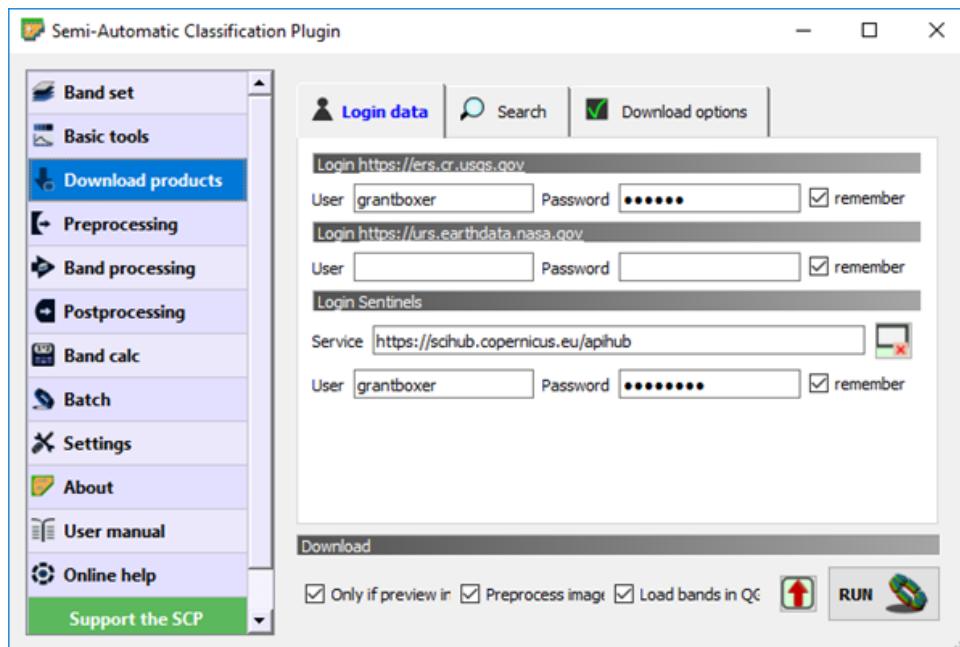
To download data you need to register with the USGS via their [EarthExplorer portal](#) (free registration) for ASTER and Landsat data and with the European Space Agency (ESA) via their [Sentinel data access portal](#). Enter these login details into the relevant sections of the SCP Download Products > Login data tab.

Note that recent changes to the USGS portal has required users to also register and login to the USGS EarthData portal before downloading data.

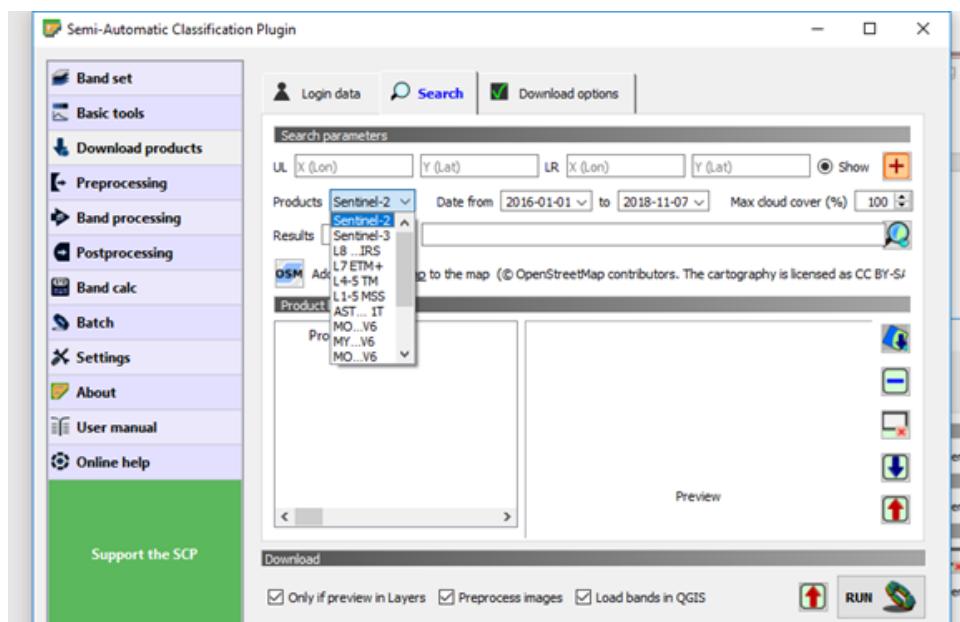
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**Note:** Make sure you click “Remember” so you don’t have to re-enter your login details each time. Logins with ESA may take a couple of days to initialise.

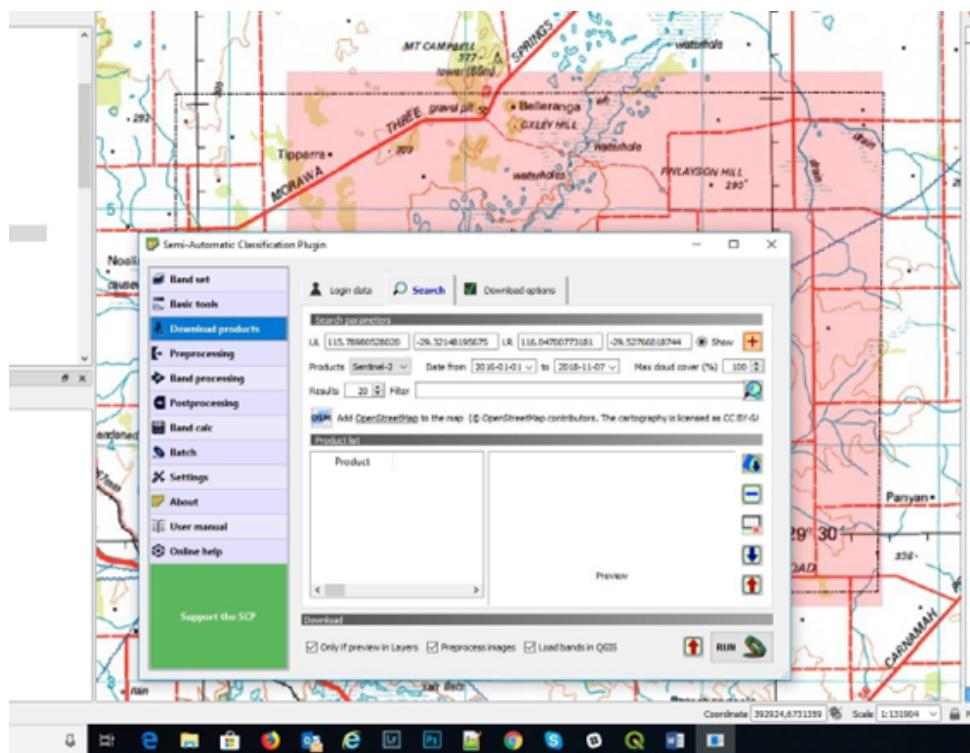
---



Once all the logins are complete, then you are ready to download data. Have the area that you wish to obtain data displayed in your QGIS map window as we will create a search area directly into this window. Click on the Search tab of the Download Products window.



The required product can be selected via the “Products” dropdown list. To select a search area, click on the orange-red cross in the top RHS of the window, then left click the top left hand side of the map area, then right click on the lower right hand side to set your search area. This will then populate the search area parameters.



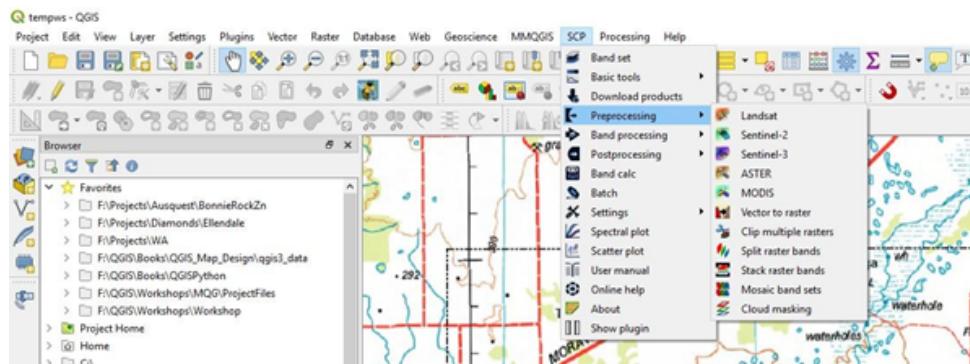
You can further refine your data search by entering for example a Sentinel 2 tile number into the “Filter” window to speed up searching and ensuring you only download the required tiles. You can select the maximum allowable cloud cover and any date ranges.

---

**Note:** For ASTER data, only download data prior to 1st April 2008 as the SWIR became non-operational after that date.

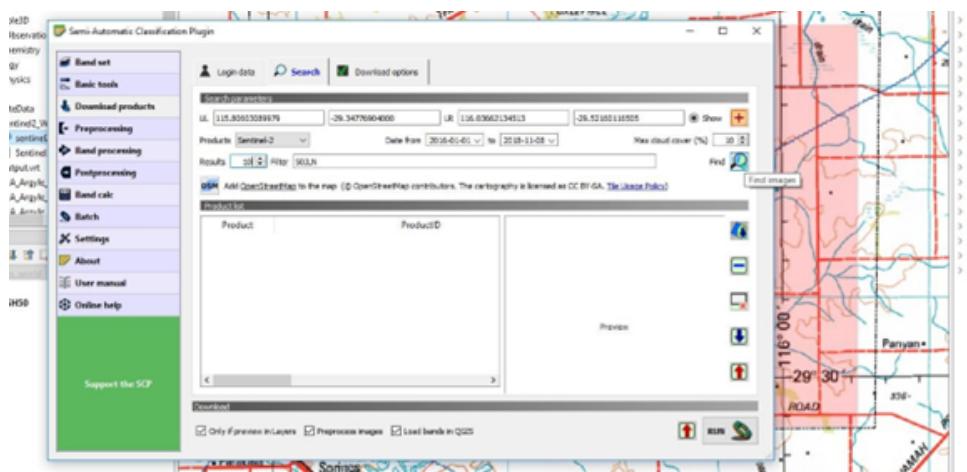
---

Once you have selected the search area, open the “Preprocessing” window.

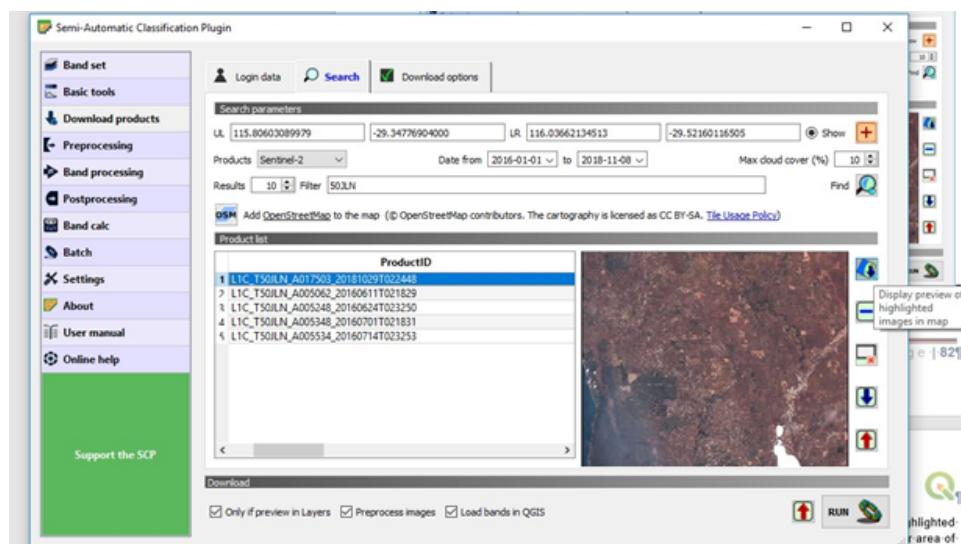


The Preprocessing window allows SCP to do atmospheric and other adjustments to the source satellite data after download, e.g. DOS 1 atmospheric correction on L1C corrected Sentinel 2 data. Note that preprocessing will only occur if the “Preprocess Images” check box is ticked in the Download window. If you download Sentinel 2 L2A data, the atmospheric corrections have already been applied. Note also the other check boxes to limit what gets downloaded and what is displayed in the map window.

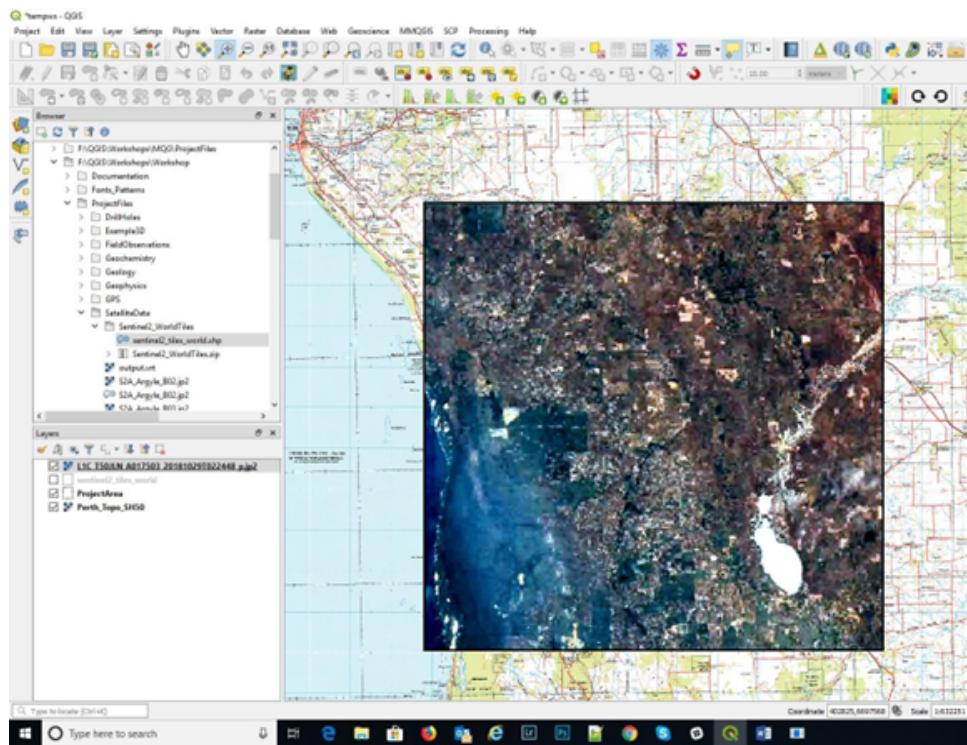
Once you have set your search parameters, click the “Find” icon.



SCP will search the data for tiles fitting the search parameters. The time to retrieve the data will depend upon internet speed. If you get a time-out error or cannot connect type message, check your login details.



A list of selected tiles will be shown in the ProductID window and each item can be highlighted and viewed in the RHS window. Note that you can now choose between Sentinel 2 L1C and L2A processing levels. The L2A data has been corrected for atmospheric effects. Check that the scene is suitable, e.g. no cloud over your area of interest, then click the icon “Display preview of highlighted images in map”. This will then download a low-resolution full scene image into your map window to ensure it covers the correct area.



To download this data, return to the Download products window and make sure the “Download” “Only if preview in Layers” is checked on. This will ensure only those layers you have in the map window will be downloaded. If all OK, click the run button and save it to the required location. The download and pre-processing may take some time, 10-20 minutes, and it is advised not to use QGIS during this time as it may crash the process. Other programs on your PC may be used.

The download process will entail downloading all the band data, then running the selected corrections, before displaying the final set of image bands into your map window. These bands can then be used to create RGB images and allow band ratios to be calculated.

Note that you can create a multiband tiff file that holds all the band data in one tiff file. This can be created via the Raster > Miscellaneous > Build Virtual Raster option, and by selecting all the bands and then using the “Highest” resolution, so that the pixel sizes of all the bands will be the same (“pansharpened to the smallest pixel size). Processing of this multiband file is now possible in the SCP or Orfeo Tool Box plugins.

The SCP Plugin also allows the user to do a multitude of other task including Principal Components Analysis (PCA). Note that to use PCA all the images must have the same pixel size, and this may require “resampling” of the image (use the Processing Toolbox > SAGA > Raster Tools > Resampling algorithm).

## 11.4 ASTER Data

Details of the ASTER (Advance Spaceborne Thermal Emission and Reflection Radiometer) scanner bands are shown in the figure below (from Abrams and Hook 2016).

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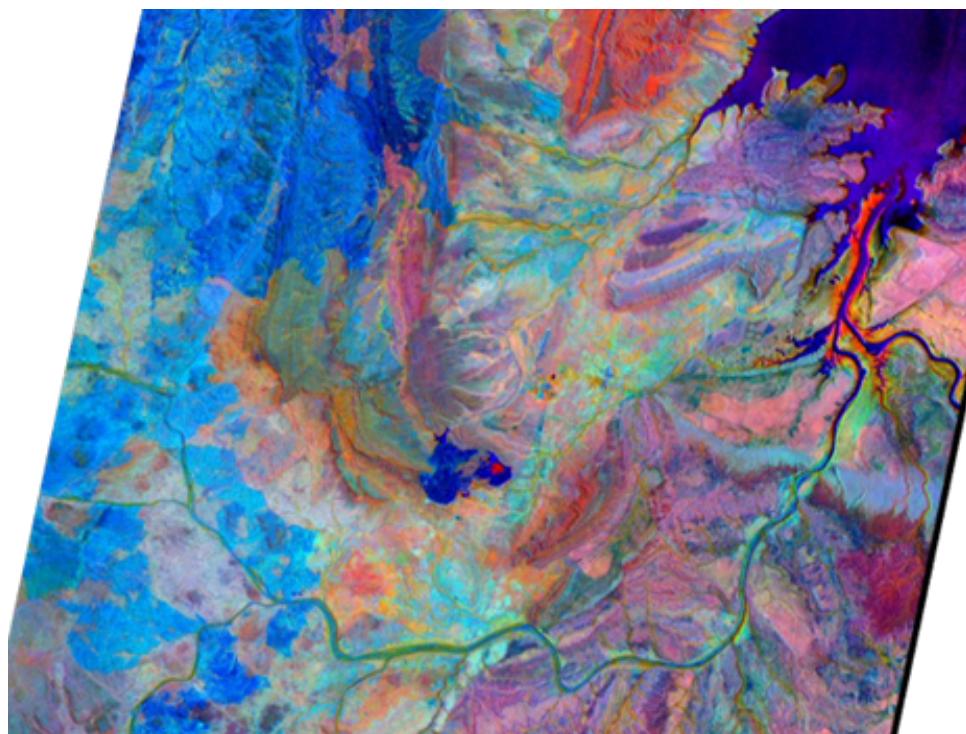
**Hint:** ASTER data is now freely available worldwide but note that the SWIR sensor (bands 4 to 9) became inoperable on 1st April 2008, and therefore only data acquired before this time will be suitable for mineral mapping.

---

## ASTER Users Handbook



Subsystem	Band No.	Spectral Range ( $\mu\text{m}$ )	Spatial Resolution, m	Quantization Levels
VNIR	1	0.52-0.60	15	8 bits
	2	0.63-0.69		
	3N	0.78-0.86		
	3B	0.78-0.86		
SWIR	4	1.60-1.70	30	8 bits
	5	2.145-2.185		
	6	2.185-2.225		
	7	2.235-2.285		
	8	2.295-2.365		
	9	2.360-2.430		
TIR	10	8.125-8.475	90	12 bits
	11	8.475-8.825		
	12	8.925-9.275		
	13	10.25-10.95		
	14	10.95-11.65		

**Table 1: Characteristics of the 3 ASTER Sensor Systems.**

An example of ASTER band combinations using ratio 4/7 (red), 4/3 (green) and 2/1 (blue) around the Argyle mine area.

ASTER bands and band ratios for geological applications are shown in the tables below (from ASTERDataProcessing\_GA7833.pdf available from Geoscience Australia).

### Common ratio & band combinations

Features	Red	Green	Blue	Reference
Vegetation and visible bands**	3, 3/2, or NDVI	2	1	
AlOH minerals/advanced argillic alteration***	5/6 (phen)	7/6 (musc)	7/5 (kaol)	Hewson (CSIRO)
Clay, amphibole, laterite	(5x7)/6 <sup>2</sup> (clay)	6/8 (amph)	4/5 (lat)	Bierwith
Gossan, alteration, host rock	4/2 (goss)	4/5 (alt)	5/6 (host)	Volesky
Gossan, alteration, host rock	6 (goss)	2 (alt)	1 (host)	
Decorellation (envi)	13	12	10	Bierwith
Silica, carbonate, basic degree index	(11x11)/10/12 (silica)	13/14 (carb)	12/13 (basic)	Bierwith
Silica, carbonate	(11x11)/(10x12)	13/14	12/13	Nimoyima
Silica	11/10	11/12	13/10	CSIRO
Discrimination for mapping	4/1	3/1	12/14	Abdelsalam
Discrimination in sulphide rich areas	12	5	3	
Discrimination	4/7	4/1	(2/3) x (4/3)	Sultan
Discrimination	4/7	4/3	2/1	Abrams (USGS)
Silica, Fe <sup>2+</sup>	14/12	(1/2) + (5/3)	MNF Band 1	Rowan (USGS)
Enhanced structural features	7	4	2	Rowan (USGS)

\*Comments by Hewson

\*\*Equivalent to Landsat RGB 432

\*\*\*Alunite/pyrophyllite, mica, kaolinite/dickite

Band ratios are easily calculated in the SCP plug-in. My personal experience for using the ASTER data in Western Australia and Peru, is that the discrimination ratios using ratio 4/7 (red), 4/3 (green) and 2/1 (blue) works well in most situations. The AlOH minerals/Advanced argillic alteration combination and the Alunite-Kaolinite-Pyrophyllite image also works well for detecting alteration associated with porphyry copper mineralisation.

### Commonly used ratios

Feature	Band or Ratio	Comments	Reference
<b>Iron</b>			
Ferric iron, Fe <sup>3+</sup>	2/1		Rowan; CSIRO
Ferrous iron, Fe <sup>2+</sup>	5/3 + 1/2		Rowan
Laterite	4/5		Bierwith
Gossan	4/2		Volesky
Ferrous silicates (biot, chl, amph)	5/4	Fe oxide Cu-Au alteration	CSIRO
Ferric oxides	4/3	Can be ambiguous*	CSIRO
<b>Carbonates / Mafic Minerals</b>			
Carbonate / chlorite / epidote	(7+9)/8		Rowan
Epidote / chlorite / amphibole	(6+9)/(7+8)	Endoskarn	CSIRO
Amphibole / MgOH	(6+9)/8	Can be either MgOH or carbonate*	Hewson
Amphibole	6/8		Bierwith
Dolomite	(6+8)/7		Rowan, USGS
Carbonate	13/14	Exoskarn (cal/dolom)	Bierwith, Nimoyima, CSIRO
<b>Silicates</b>			
Sericite / muscovite / illite / smectite	(5+7)/6	Phyllitic alteration	Rowan (USGS); Hewson (CSIRO)
Alunite / kaolinite / pyrophyllite	(4+6)/5		Rowan (USGS)
Phengitic	5/6		Hewson
Muscovite	7/6		Hewson
Kaolinite	7/5	Approximate only*	Hewson
Clay	(5x7)/6 <sup>2</sup>		Bierwith
Alteration	4/5		Volesky
Host rock	5/6		Volesky
<b>Silica</b>			
Quartz rich rocks	14/12		Rowan
Silica	(11x11)/10/12		Bierwith
Basic degree index (gnt, cpx, epi, chl)	12/13	Exoskarn (gnt, px)	Bierwith, CSIRO
SiO <sub>2</sub>	13/12	Same as 14/12	Palomera
SiO <sub>2</sub>	12/13		Nimoyima
Siliceous rocks	(11x11)/(10x12)		Nimoyima
Silica	11/10		CSIRO
Silica	11/12		CSIRO
Silica	13/10		CSIRO
<b>Other</b>			
Vegetation	3/2		
NDVI	(3-2)/(3+2)	Normalised difference vegetation index	

### Other possibly useful ASTER band calculations and combinations are listed below.

- Abrams Ratio - 5/7, 4/5 and 3/1 in RGB
- Sabin Ration - 5/7, 3/1 and 3/5 in RGB
- Porphyry Alteration Index - 4, 6 and 8 and RGB (advanced argillic and phyllitic alteration in pink to red colours)
- Alunite and kaolinite enhanced by 4/5 or 4/6
- Sericite - phyllitic alteration enhanced by 5/6
- Propylitic alteration enhanced by 5/8

Mineral Indices of Ninomiya (2004)

- OH Minerals Index - (Band 7/ Band 6) \* (Band 4/Band 6)
- Kaolinite Index - 4/5 \* 8/6
- Alunite Index - 7/5 \* 7/8
- Calcite Index - 6/8 \* 9/8

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**Note:** Remember the resulting images may have artefacts caused by low sun angles, clouds, etc. so be cautious in using the data. Remote sensing vendors can undertake more advanced processing and interpretation of this data, and the rough processing described herein should be used with caution.

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## 11.5 Landsat Data

Landsat 8 data is collected over 11 bands as illustrated below.

Band Reference Number	Band Description	Band Center (nm)
1	Coastal Aerosol (Operational Land Imager (OLI))	433
2	Blue (OLI)	482
3	Green (OLI)	562
4	Red (OLI)	655
5	Near-Infrared (NIR) (OLI)	865
6	Short Wavelength Infrared (SWIR) 1 (OLI)	1610
7	SWIR 2 (OLI)	2200
8	Panchromatic (OLI)	590
9	Cirrus (OLI)	1375
10	Thermal Infrared Sensor (TIRS) 1	10800
11	TIRS 2	12000

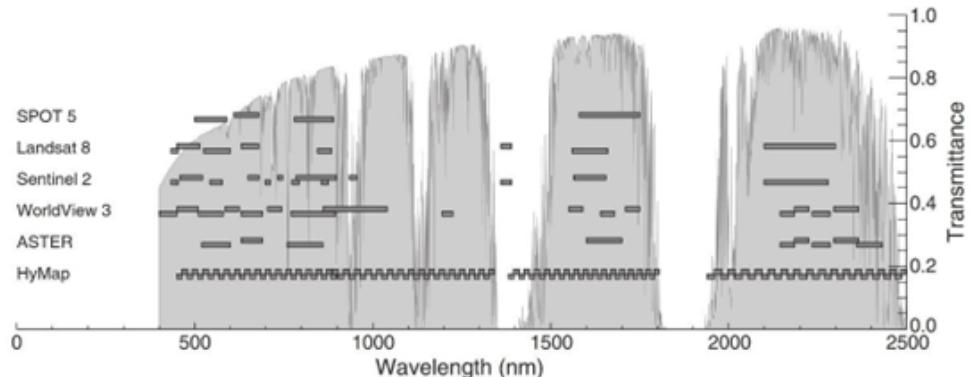
Landsat 8 band combinations are usually bands 4, 3 and 2 in the R, G and B channels for an aerial photo type image, whereas the combination of bands 6, 4 and 2 typically enhances the geology. Band 8 is used to pan-sharpen the 30 m images to 15 m resolution. The SCP plug-in will automatically pan-sharpen the RGB images if this option is selected.

Table 3: A recent article by Ito et al (2022) uses a series of indices to analyse the geology in Landsat scenes as follows;

Index Number	Index Name	Formula
1	Ferric Iron “redness”	4/2
2	Ferric Iron 2	(4/2)*((4+6)/5)
3	Ferrous iron, coarse grained ferric iron	(3+6)/(4+5)
4	Clay, sulphate, mica, marble	(6/7)/(5/4)
5	Iron sulphate	(2/1)-(5/4)

## 11.6 Sentinel 2 Data

The Sentinel 2 satellites are designed for earth observation and the figure below illustrates the comparison with the other satellite data bands (from van der Meer et al 2014). The Sentinel satellite constellation has been launched by the European Space Agency (ESA) and the derived data is available free of charge. See [ESA website](#) for more detail on the available data and data access. You need to register (free) on the Sentinel web site to be able to download the Sentinel data.



When using Sentinel 2 data, it is recommended to use bands 4, 3 and 2 (for RGB) for the natural aerial photo type image and a combination of bands 12 or 11, 4 and 2 (for RGB) which can enhance the geology in a scene. Users should experiment with various band ratios to find which is the most suitable for their application.

Table 4: The following list of recommended band combinations is from the Sentinel education web page

Index Name	Formula
Natural Colour	B4 (red), B3 (green), B2 (blue)
Colour Infrared (vegetation)	B8, B4, B3
False Colour (Urban)	B12, B11, B4
Agriculture	B11, B8, B2
Vegetation Index	(B8 - B4)/(B8 + B4)
Moisture Index	(B8A - B11)/(B8A + B11)
Geology	B12, B4, B2
Bathymetric	B4, B3, B1
Atmospheric Penetration	B12, B11, B8A
SWIR	B12, B8A, B4
NDWI	(B3 - B8)/(B3 + B8)
SWIR-2	B2, B11, B12

Another useful band combination for a “Regolith Ratio” image is 11/12 (red), 8A/12 (green) and 8A/3 (blue) (from Mark Arundel).

The figure below from van der Meer et al 2014 compares ASTER ratio mineral mapping to the equivalent bands in the Sentinel 2 data.

Sentinel-2 band ratios as an analogue of ASTER band ratios, used as proxies for mineralogy. Modified after Kalinowski & Oliver (2004). The table is limited to ratios that fall in the wavelength range of Sentinel-2.

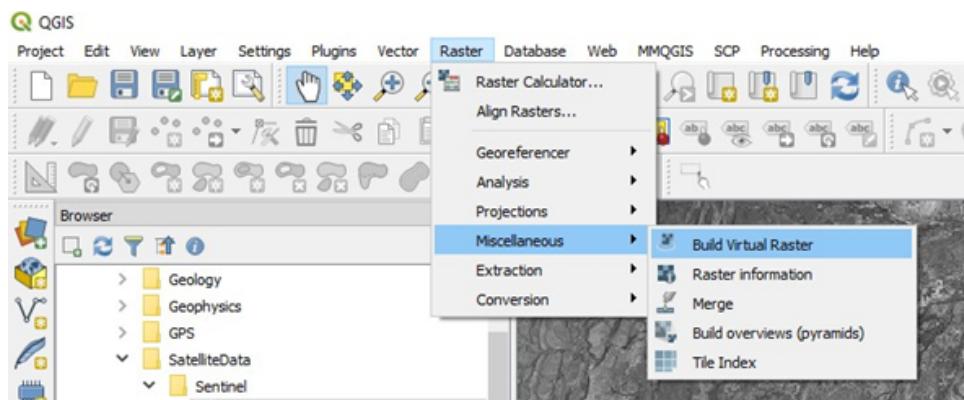
Feature	ASTER	Sentinel-2
<b>Iron</b>		
Ferric Iron, Fe <sup>3+</sup>	2/1	4/3
Ferrous Iron, Fe <sup>2+</sup>	5/3 + 1/2	12/8 + 3/4
Laterite	4/5	11/12 <sup>a</sup>
Gossan	4/2	11/4
Ferrous silicates (Biotite, chloride, amphibole)	5/4	12/11 <sup>a</sup>
Ferric oxides	4/3	11/8
<b>Carbonates/Mafic minerals</b>		
Carbonate/Chlorite/Epidote	(7 + 9)/8	-
Epidote/Chlorite/Amphibole	(6 + 9)/(7 + 8)	-
Amphibole/MgOH	(6 + 9)/8	-
Amphibole	6/8	-
Dolomite	(6 + 8)/7	-
<b>Silicates</b>		
Sericite/Muscovite/Illite/Smectite	(5 + 7)/6	-
Alunite, Kaolinite, Pyrophyllite	(4 + 6)/5	-
Phengitic	5/6	-
Muscovite	7/6	-
Kaolinite	7/5	-
Clay	(5 × 7)/6 <sup>2</sup>	-
Alteration	4/5	11/12 <sup>a</sup>
Host rock	5/6	-
<b>Other</b>		
Vegetation	3/2	8/4
NDVI	(3 - 2)/(3 + 2)	(8 - 4)/(8 + 4)

<sup>a</sup> ASTER bands 5–7 fall within band 12 of Sentinel-2.

## 11.7 Creating RGB Images

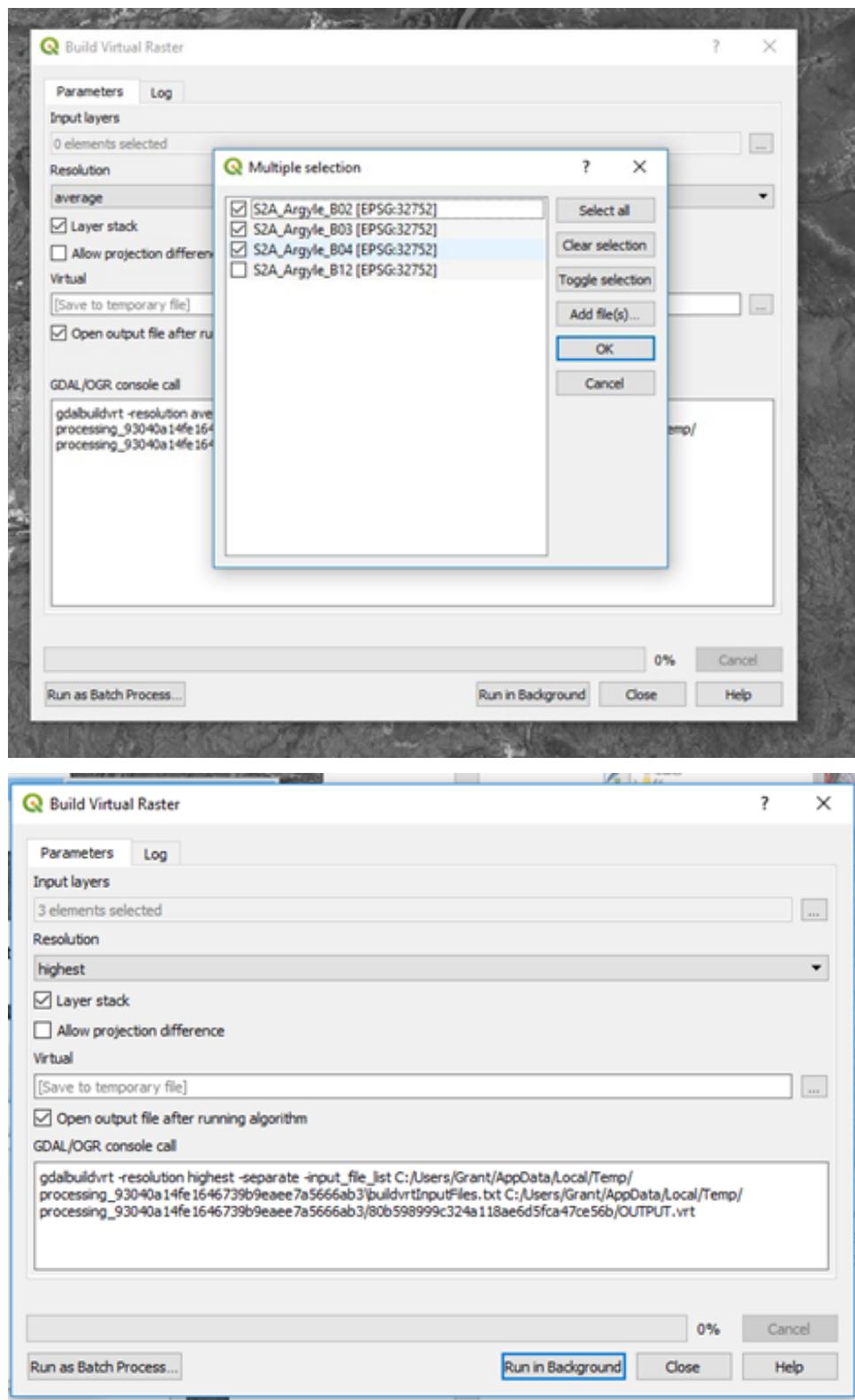
There are two methods available to create a coloured image (“rgb”) of remote sensing or any other 3 band data set. We can use the Raster > Miscellaneous > Build Virtual Raster option or the “Virtual Raster Builder” plugin.

The Raster option is shown below.



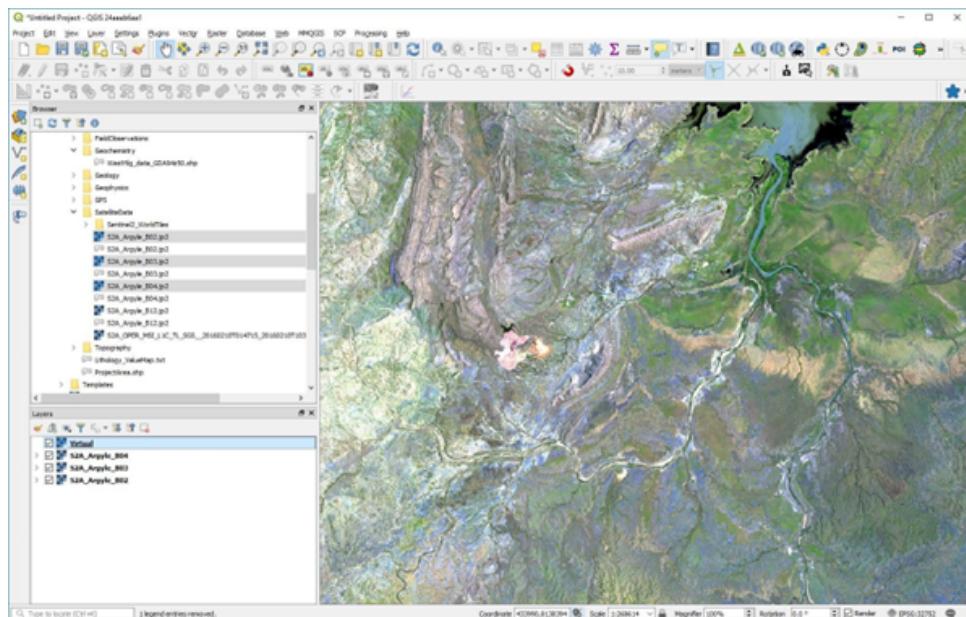
The Build Virtual Raster window will be displayed. Select the input layers as the ones to use for the RGB

composite. Ensure you have the files in the correct order as it assigns the red channel to the top image, green to the middle image and blue to the lower image in the selection panel.

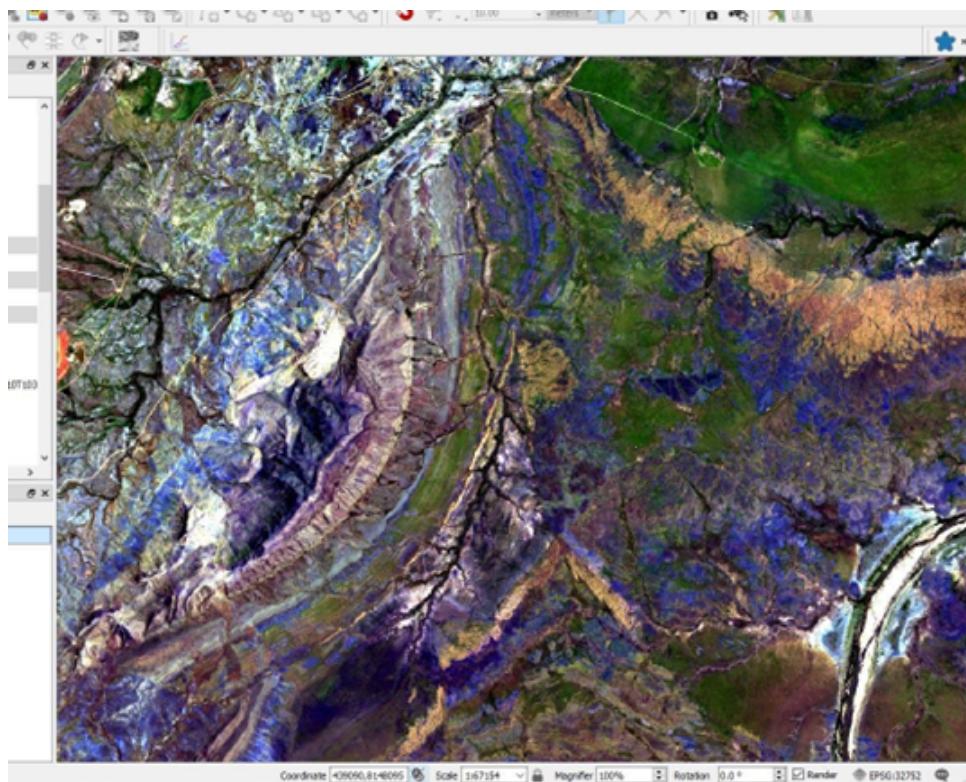


Select the “Highest” resolution to ensure you obtain the highest resolution possible and is similar to “pansharpening” where the larger pixels will be resampled to match the smaller pixels. Press “Run in Background” and the composite colour image will be produced as a virtual image.

To save this file permanently, you need to right-click on the “Virtual” file name and save as a “Rendered” RGB image and any chosen file format, usually GeoTiff.

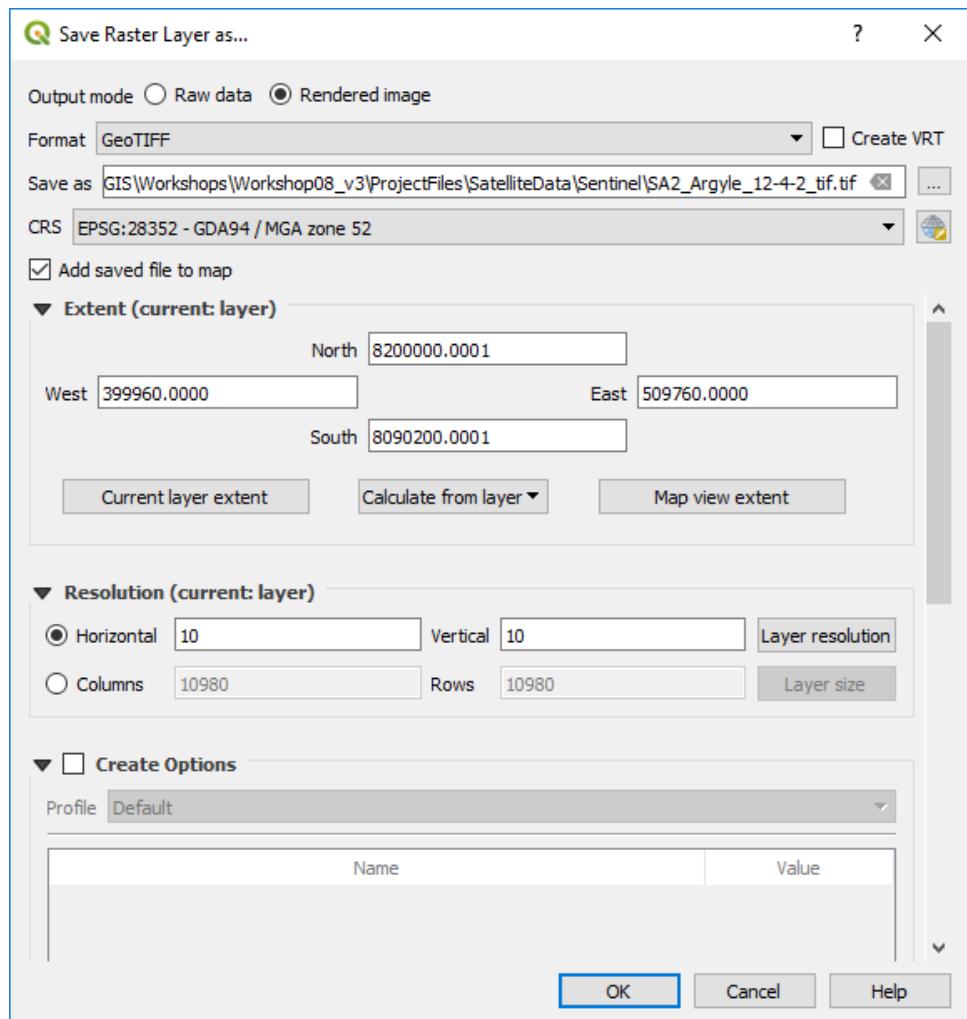


To adjust the colour stretch, zoom into a part of the image where you want to see more detail and then use the Layer panel to right click on the RGB layer and select “Stretch using current extent”. This can be done multiple times until you get the desired result (see below for example). Alternatively, you can activate the “Raster Toolbar” and use the toolbar to adjust the colour stretch.



The “Virtual” RGB image is currently only a temporary file. To create a permanent image, right click on the image layer in the Layers panel and select “Save As” Select the “Rendered Image” option, click the “Browse” and select the folder and required file name. Change the coordinate system if required. When all is OK, click OK. It may take some time to create the tiff file depending upon the size of the image and the speed of your computer.

The resulting RGB image can be saved via the Save Raster layer option.



Note there are options for saving as a geopackage or GeoTiff file and modifying the output projection  
GeoPackage files are much more compact (smaller) than equivalent GeoTiff files.

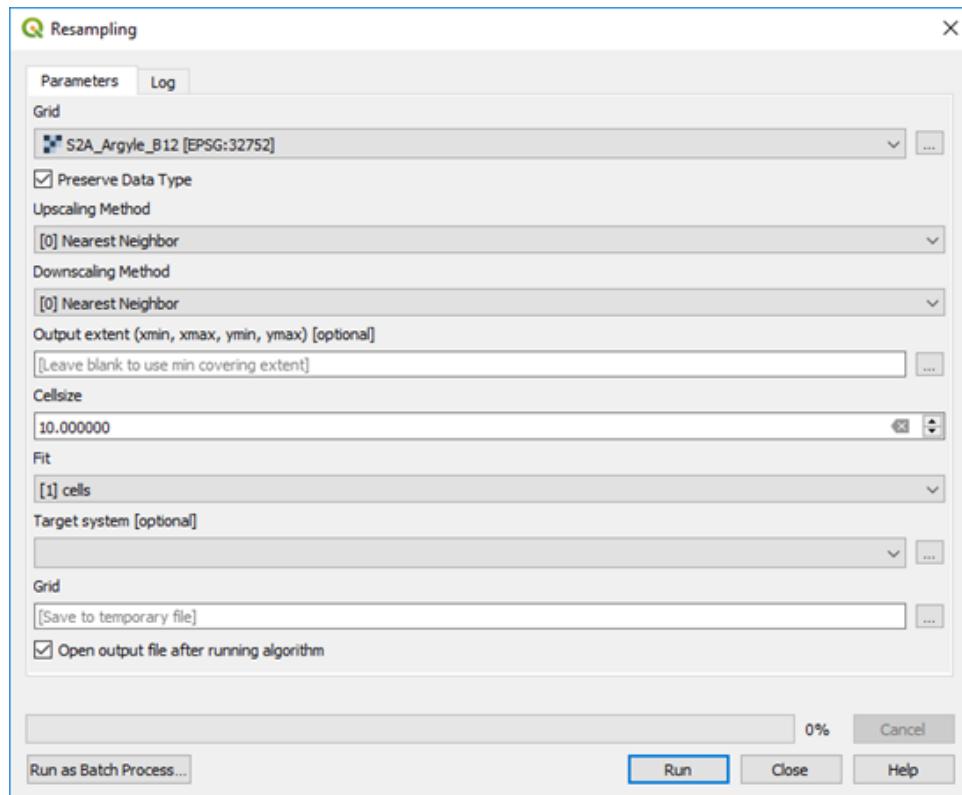
To merge adjacent satellite images/bands, initially try the Raster > Miscellaneous > Build Virtual Raster option. If this is unsuccessful, or creates large blanks between images, try the using the Processing Toolbox > SAGA > Raster tools > Mosaic raster layers. Option settings that have worked in merging adjacent ASTER scenes are: | Interpolation - “4 B-Spline” | Overlapping areas - “6 feathering” | Blending distance - “1000” | Match - “regression” | Cell size - “15” (or 30 m, 60 m, 90 m - to match the relevant pixel sizes for the images being merged) | Fit - “Cells” | and save to a file. All other setting as default.

If you have problems merging adjacent satellite images where you get edge effects between adjacent scenes, try downloading and installing [SAGA](#). This a powerful and free GIS analysis program and has a good help file. The mosaicking option is found in the Geoprocessing > Grid > Grid System > Mosaicking menu item. Use the Match option “match histograms of overlapping area”.

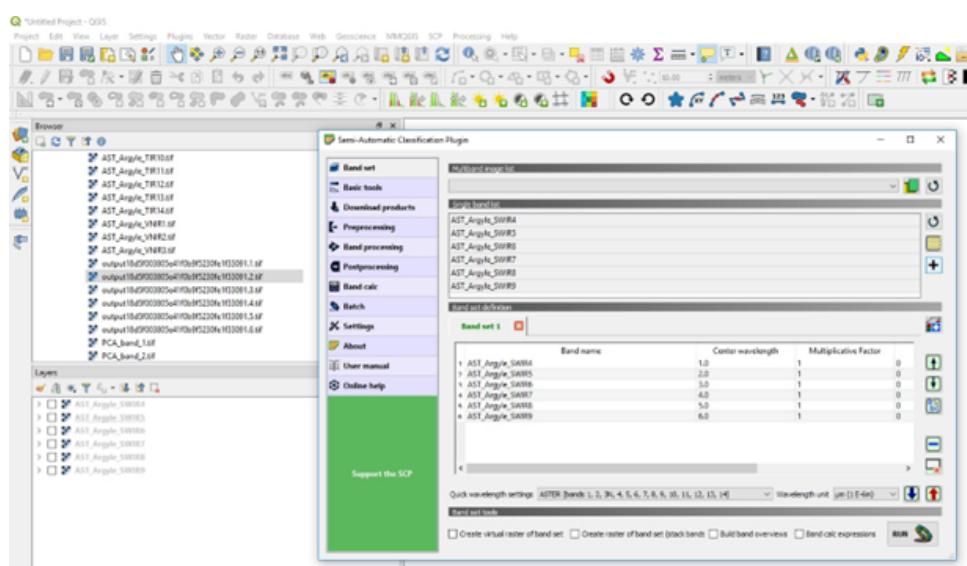
## 11.8 Principal Components Analysis (PCA)

Principal Components Analysis (PCA) can be undertaken using the Semi-Automatic Classification plugin or via the [Orfeo Tool Box](#). The input files for the PCA analysis require they have the same pixel size and may require resampling if necessary (see Processing Toolbox > SAGA > Raster Tools > Resampling). The easiest way to ensure a common pixel size is to create a multiband raster using the Build Virtual Raster and selecting the “Highest” resolution option.

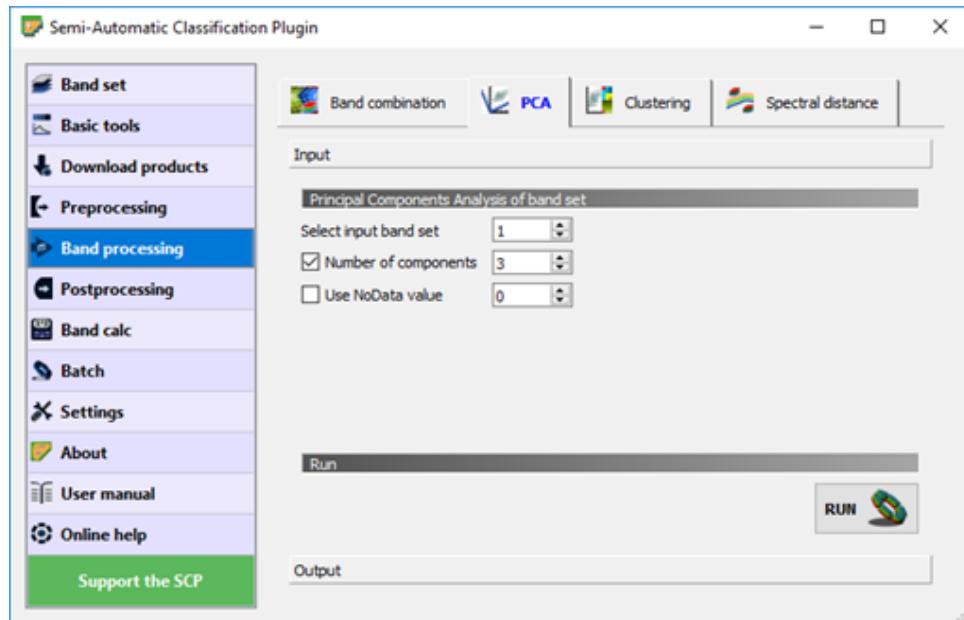
If you need to resample the raster to a different cell/pixel size, ensure you check the cell size and “Fit” to cell, otherwise it will offset the resulting image.



In the SCP plugin, create a Band Set using the Band Set tab. Press refresh to show what bands are available (in the Layers panel) then select the layers to be used for the band set - highlight the required bands, then click the plus symbol “Add band to band set”. This set of bands will be used in the PCA analysis.



Click on the Band Processing tab and select PCA. Check that the input band set is correct, select 3 components (required for an RGB colour image) and press Run. Select the target directory for the results to be saved. Note in the image above I have used the SWIR ASTER bands for the PCA analysis.



This process will produce three PCA images, PCA1, PCA2 and PCA3. Use the Virtual Raster Builder plugin to produce the RGB image (as above).

# CHAPTER 12

## MAP PRODUCTION

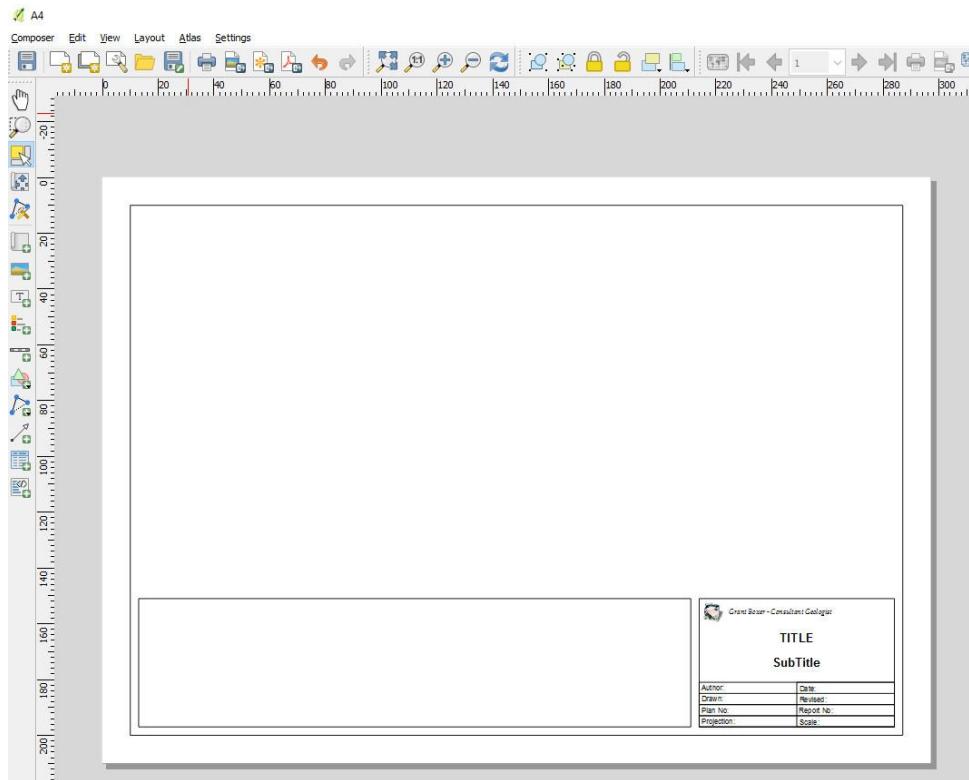
### 12.1 Print Layout

The Print Layout is the tool to produce maps for output. Various standard page sizes can be selected as well as creating custom sizes. Everything to do with the final map design is done in the print layout. If you lose tab views, click on the “Views” menu option in the layout window and scroll down to Panels to reselect them for display.

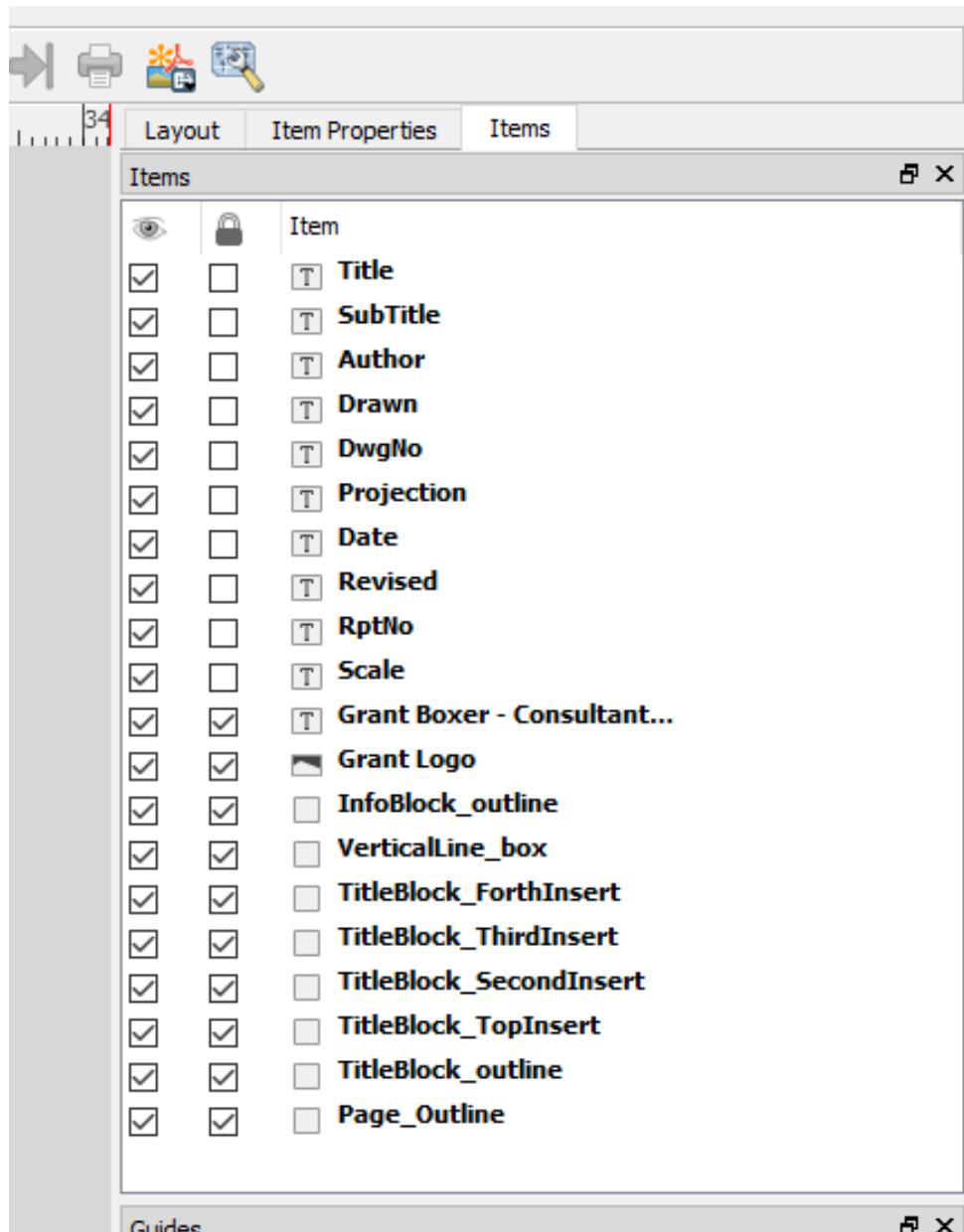
To ensure you get true scale plots, it is important to have the main map projection in a metres projection (i.e. UTM) and not in a geographic lat/long projection. Problems may be created with the scale not being correct on the map output when the main map window is in a lat/long projection.

### 12.2 Map Templates

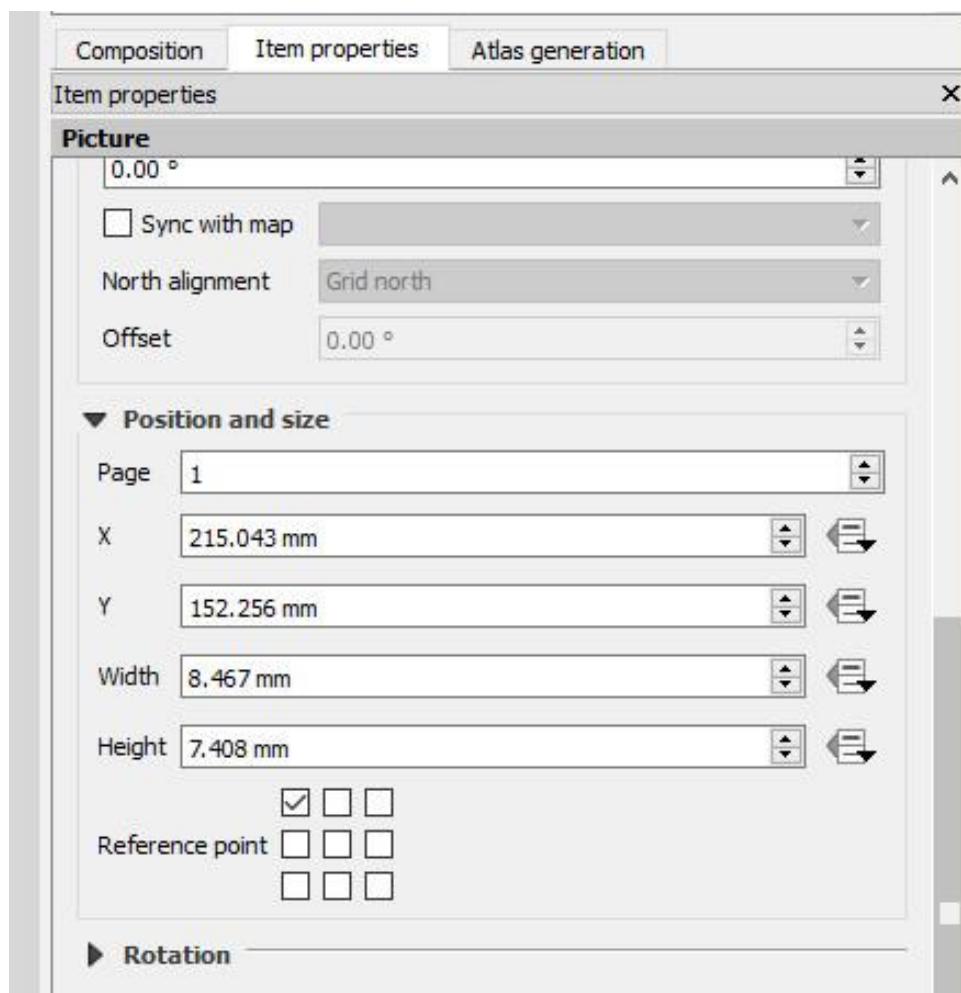
Templates can be constructed for use with a variety of map sheets sizes, e.g. A4, A3, A2, A1 and A0 in either landscape or portrait orientation. Frames and title blocks are simply constructed as rectangles and standard text boxes added into the rectangles. Shapes and text boxes are selected from along the left-hand side margin of the map composer window. The figure below illustrates an example of a template complete with title block. Templates can be dragged into the print layout window from the Browser panel, which will then automatically set the correct page size.



Each item of the template is listed in the Item panel and can be turned on or off and edited. Note that the position of the features can be set and adjusted using the “Position and Size” options in the item properties dialog box. Each item, e.g. page frame, insert box, logo, etc., has its own item properties and these can be varied independently.

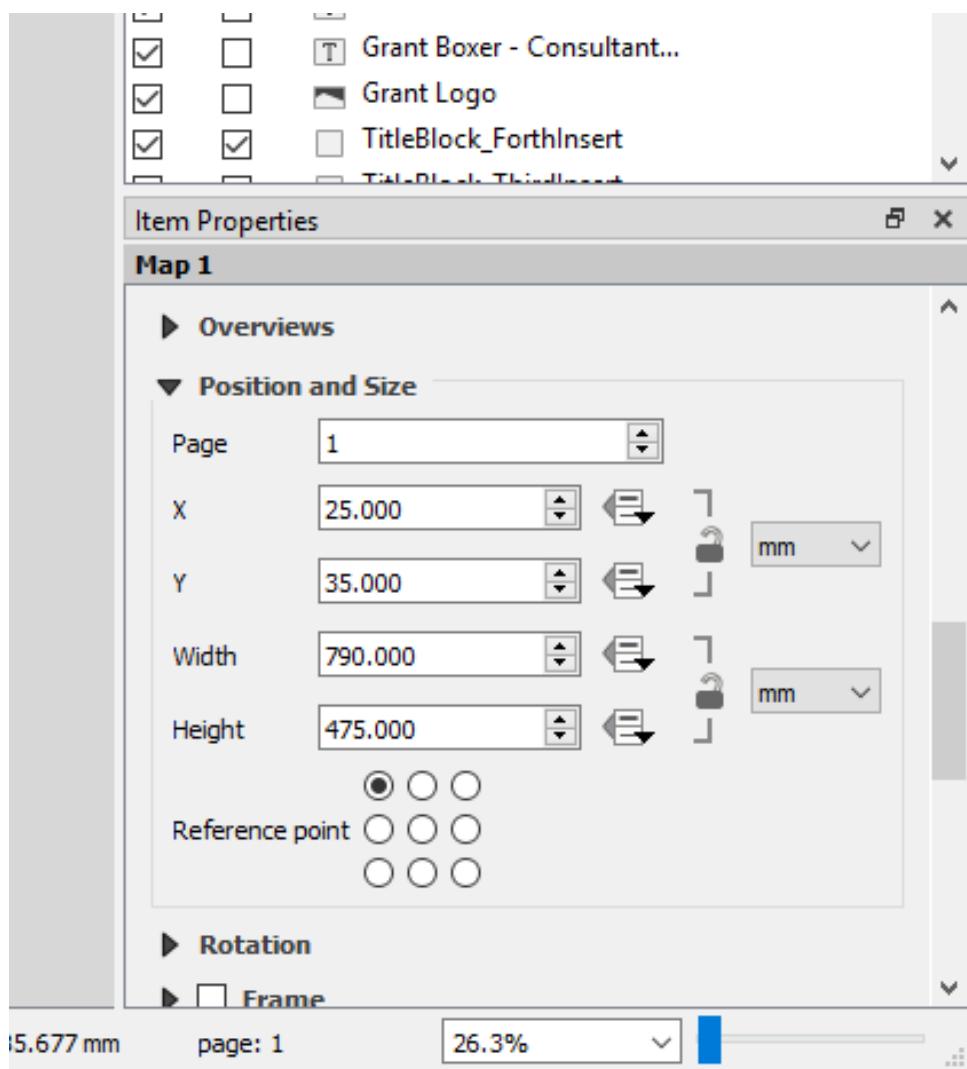


The image above shows all the items that map up the map frame.



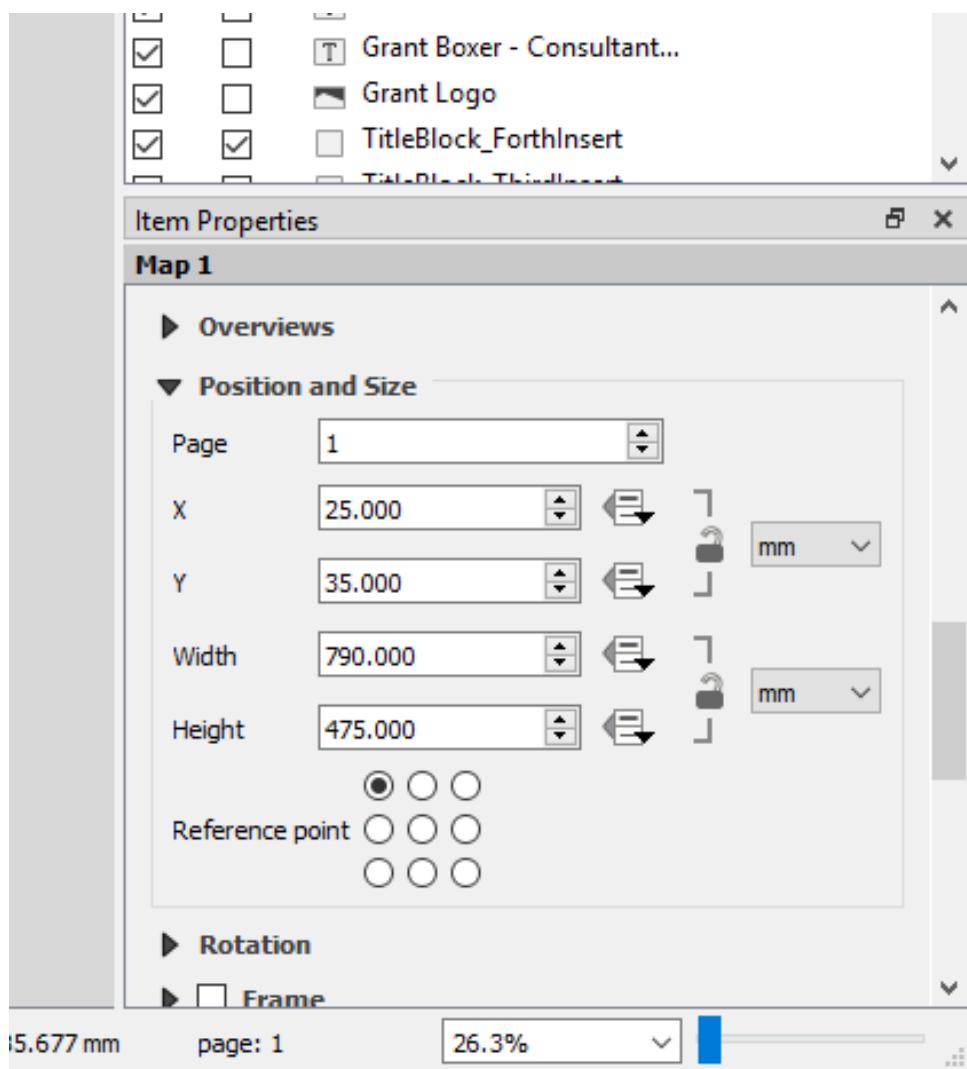
The example above is the “Logo” item (diamond image on the layout) and its location is referenced to the top left-hand corner of the page as shown in the 3 x 3 box array. It is located 215 mm to the right and 152 mm below the top left hand corner of the page, with a width of 8 mm and a height of 7 mm.

Each text box has a location and is edited as required in the Label > Main Properties window. The image below shows the “Author” field selected and the details can then be added to the existing text, or changed as required. If the text boxes require adjustment, use the position and size options attached to the item.

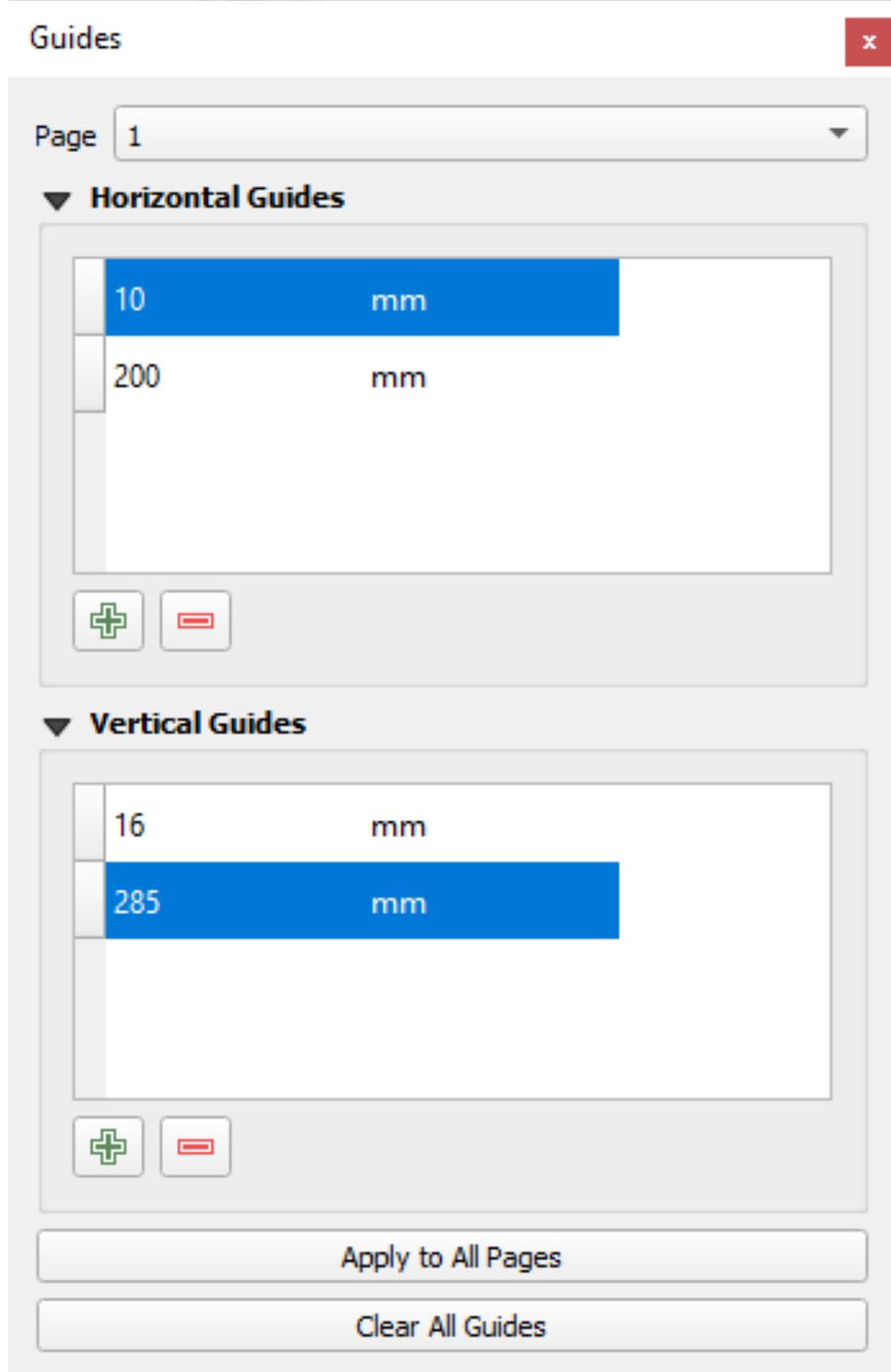


Note that these templates may require adjustments for different printers and plotters depending on their “print area”.

The position and size of the inserted map window can be adjusted under the “Map” item properties and using the “Position and Size” options. The reference point in the figure below shows the measurements from the top LHS of the page.

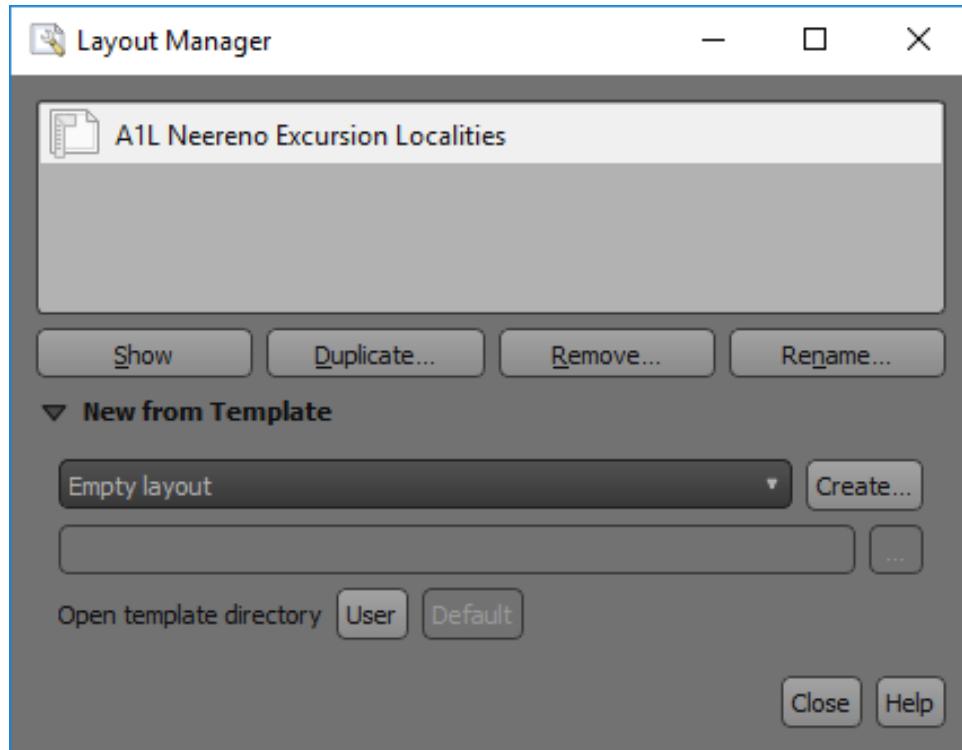


To insert a map of fixed/pre-determined size, in the Print Layout, select the View > Manage Guides and set the horizontal and vertical guidelines. The inserted map windows can then be adjusted to fit these guidelines. Grids can also be used to align map items.



## 12.3 Layout Manager

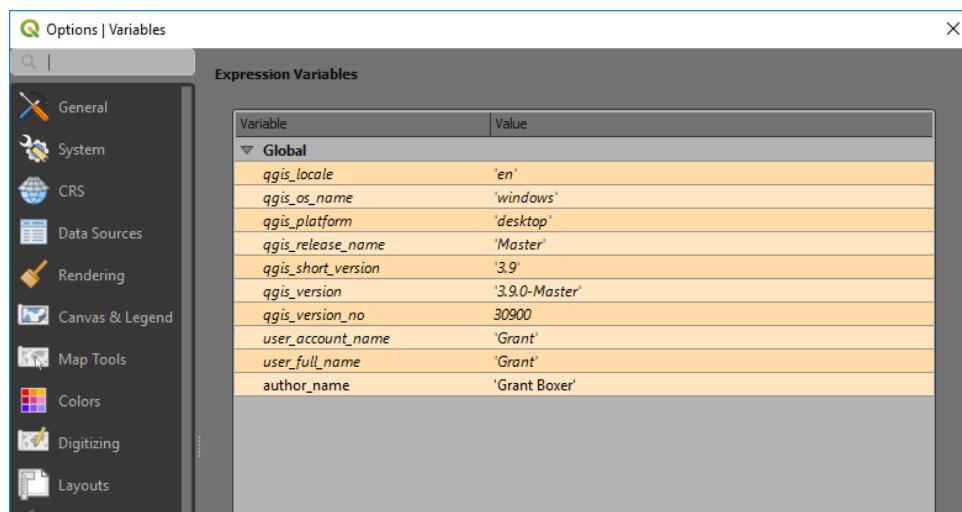
The layout manager shows what layouts are attached to the project. You can have many layouts of different sizes and configurations all saved with the project. If you have a set layout where you need different themes on maps, you can use the duplicate button to make a copy of the layout. Note that you need to “lock” layers in a layout to prevent a refresh from re-drawing the layout display.



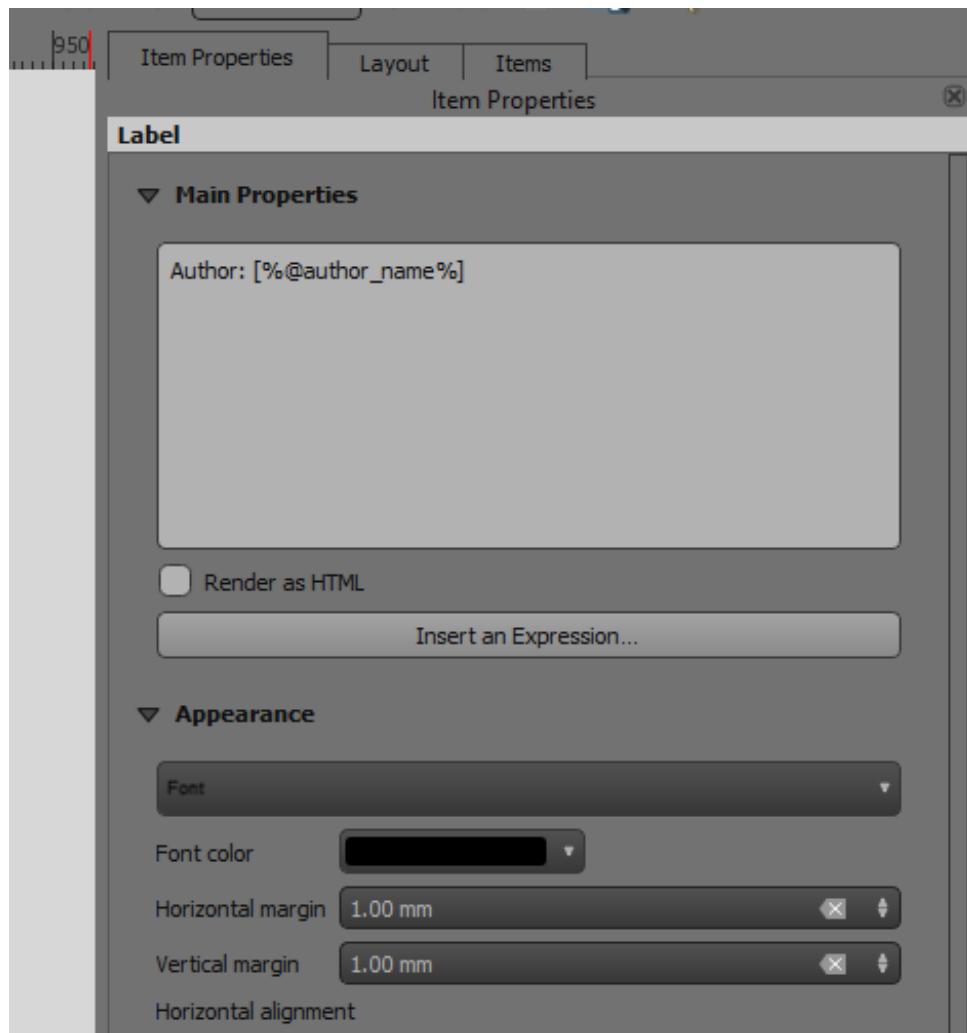
## 12.4 Using Variables to Display Information

Variables can be used to populate information in text boxes, e.g. the map author’s name, QGIS version, or the file path to the Project file. There are various types of variable and they can be applied globally, for a specific project or layout.

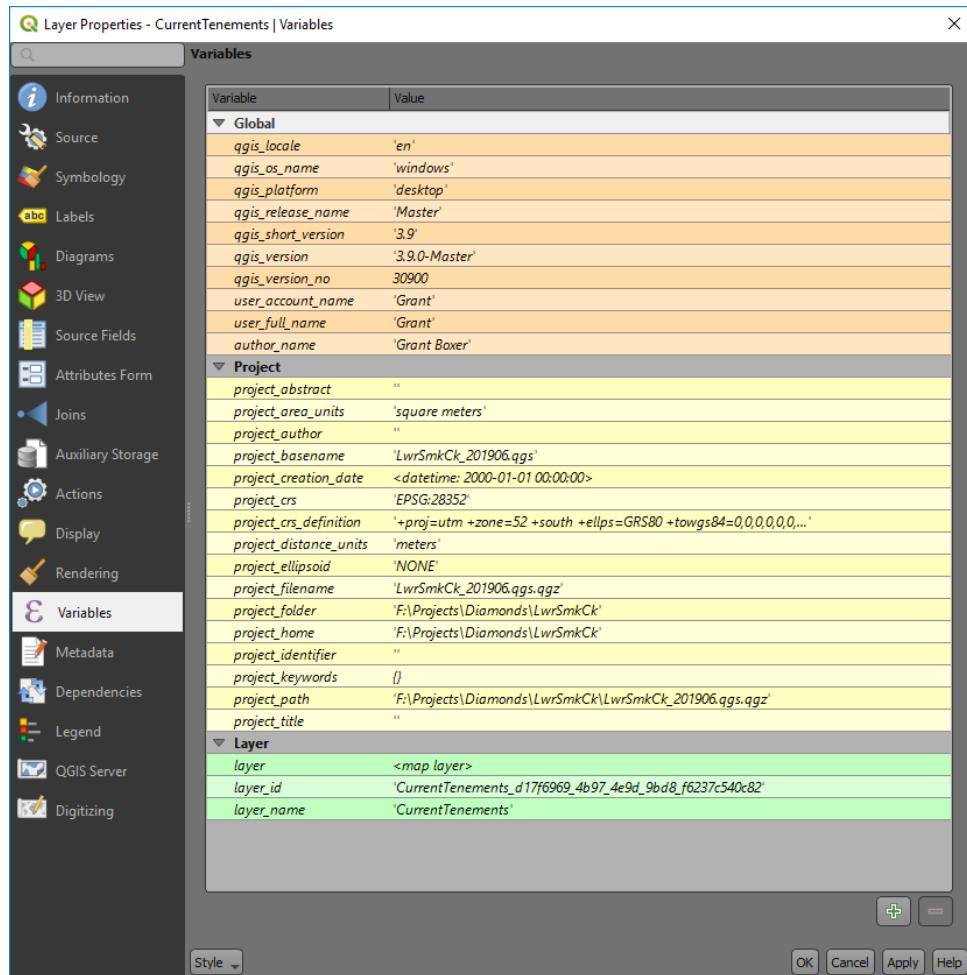
Global variables apply to QGIS overall and they can be found in the main menu item Settings > Options and the Variable tab.



A number of default global variables are added by QGIS. Note that I have added a new variable name “author\_name” with its value being Grant Boxer. I can then use this variable to add my name anywhere on a layout by using the [%@author\_name%] statement.



There are similar windows for the Project Properties and Layer Properties.



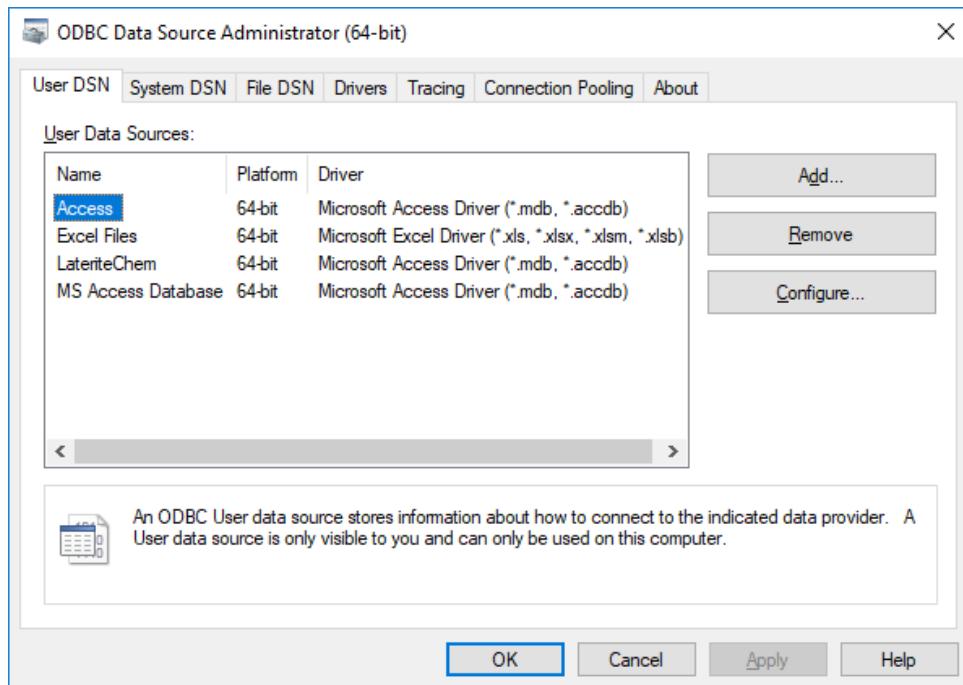
# CHAPTER 13

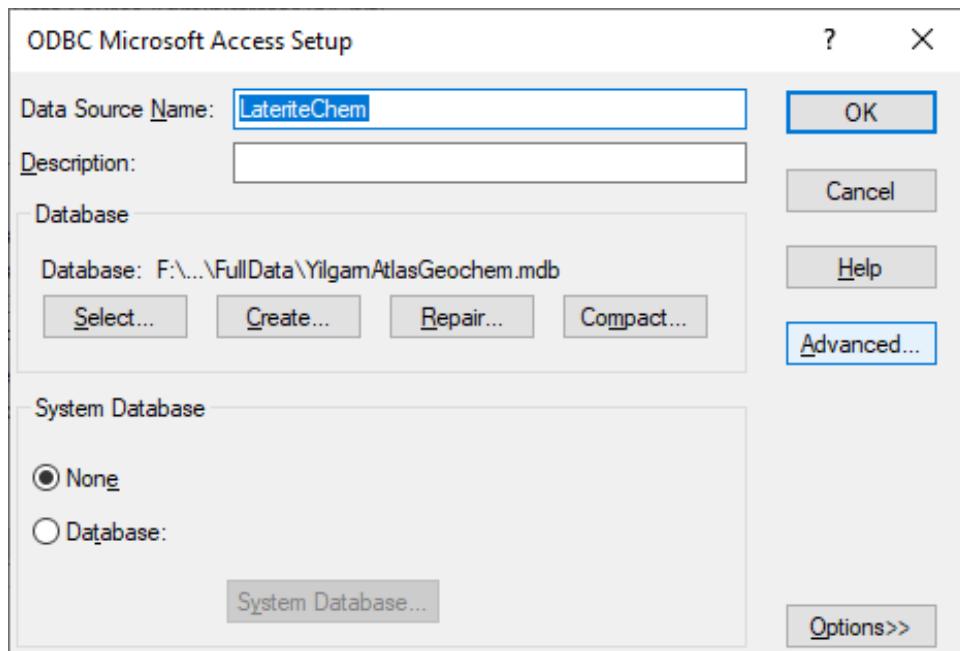
## MISCELLANEOUS TRICKS AND TIPS

### 13.1 Access Databases

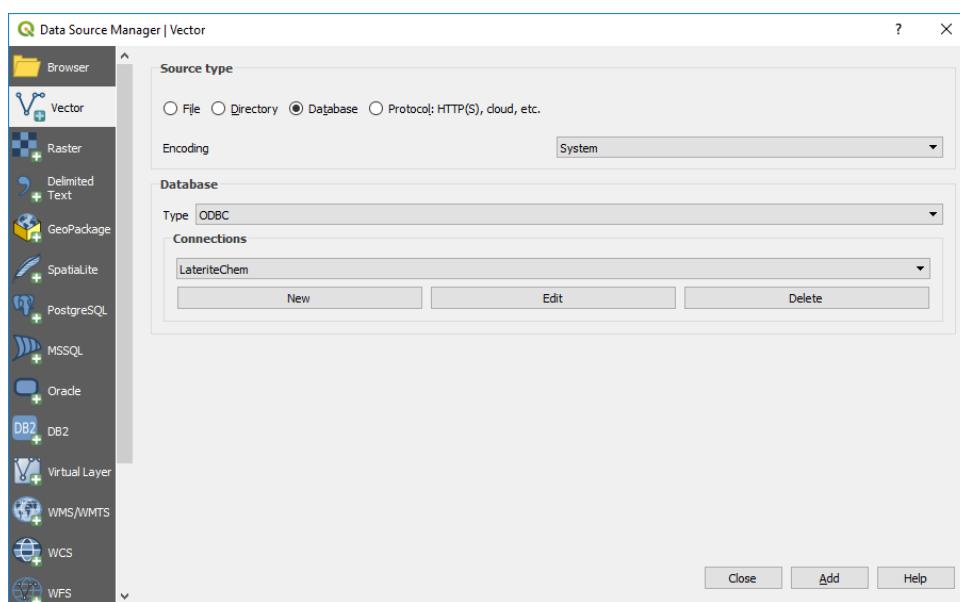
Connecting to an Access database requires some additional steps than required for the open source database programs.

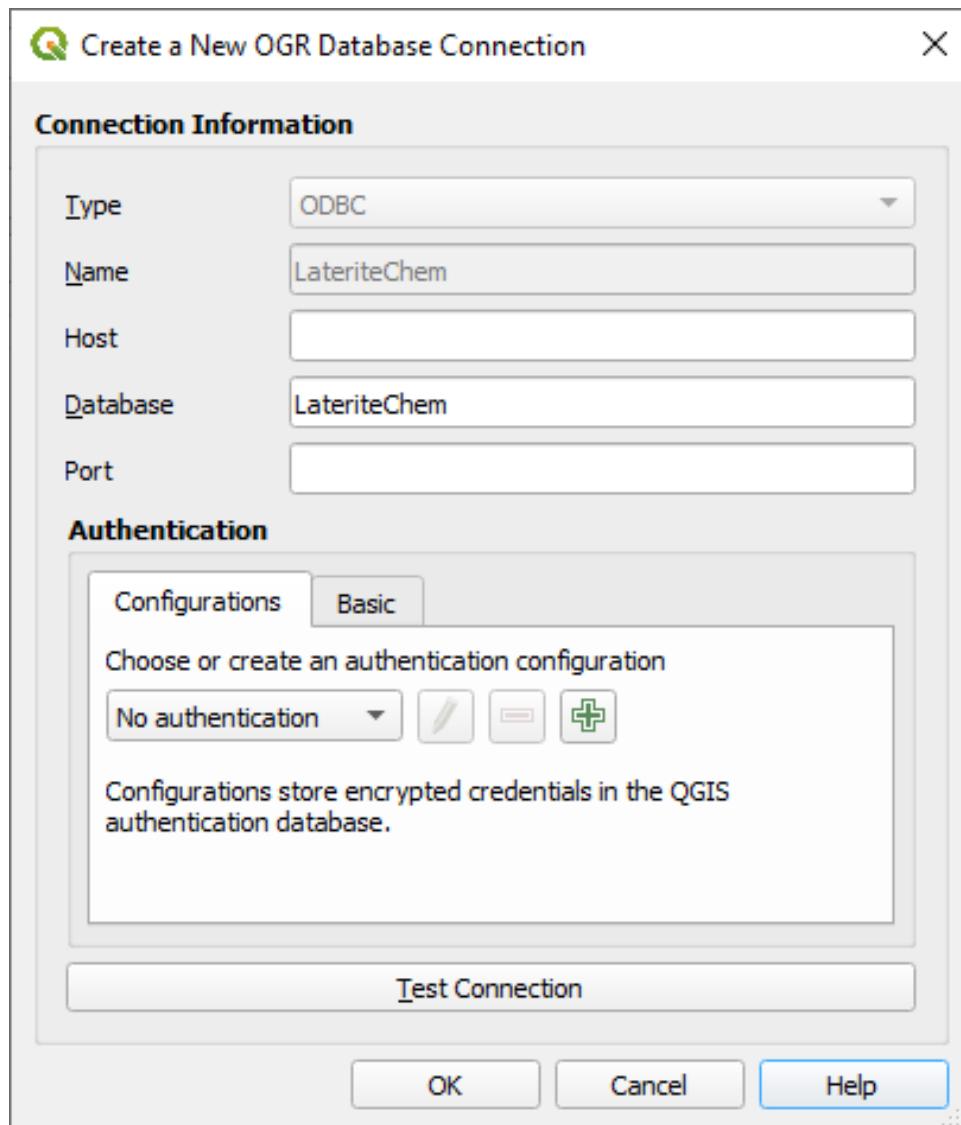
Open the 64-bit ODBC admin window (via the Windows search box) and add another “Access 64-bit line”, select the database name and location in the User DSN tab - e.g. “LateriteChem”.





In the Open Data Source Manager, select the Add Vector option, and type of Database. Connect to the database and Add.





The next window will display the tables available for import.

Layer ID	Layer name	Number of features	Geometry type
0	AtlasAnalyses	0	Unknown
1	AtlasAnalysesPGE	0	Unknown
2	AtlasAnalysisLog	0	Unknown
3	AtlasLaboratory	0	Unknown
4	AtlasMethods	0	Unknown
5	AtlasSampleCharacteristics	0	Unknown
6	AtlasSampleDetails	0	Unknown
8	Extract flat table	0	Unknown
7	Standards: AnalysesStandards	0	Unknown

OK Select All  Add layers to a group Cancel

If the table has spatial data, e.g. coordinates, then after import, use the Processing Toolbox > Algorithms > Vector Creation > Create Points Layer from Table, and select the field for the coordinates and the applicable Coordinate Reference System.

## 13.2 AutoSaver Plug-In

The Auto-Saver plug-in will save your project at regular intervals. I have had problems with this turned on during digitising and I recommend it is turned off when creating new files.

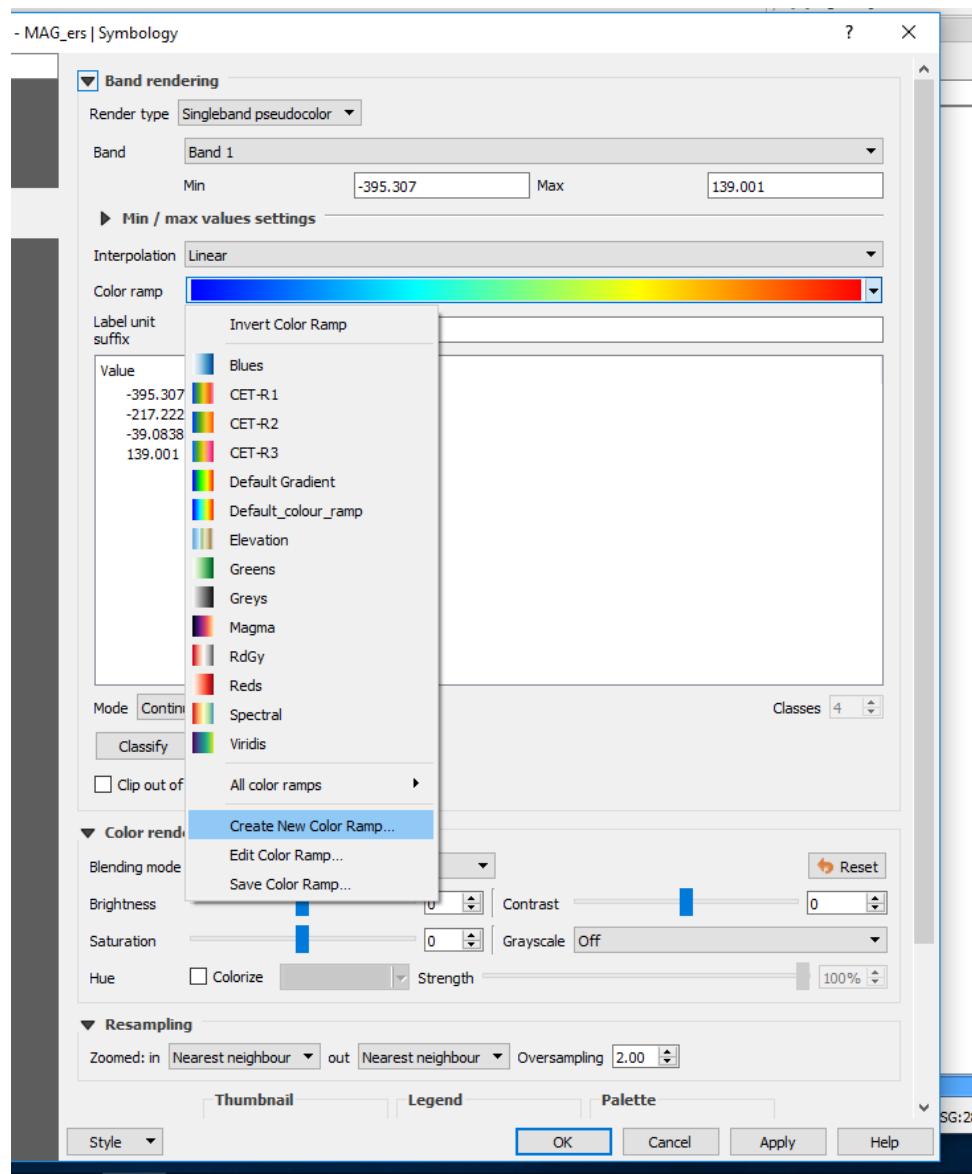
## 13.3 Spatial Bookmarks

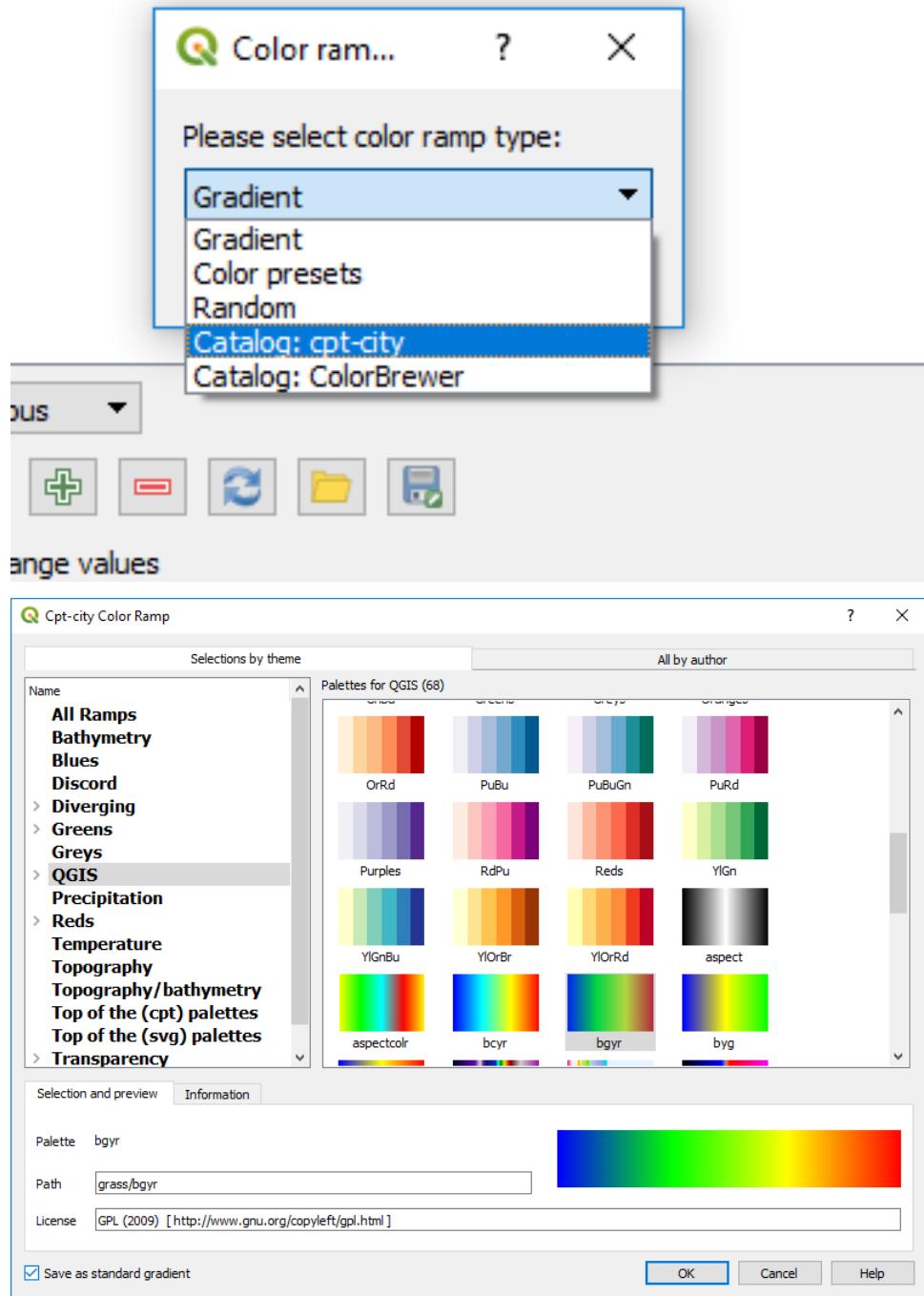
Bookmarks are used to remember the extents of a map window and they are saved with the project data. When a bookmark is saved, the bookmark list panel is displayed. Bookmarks are created via View > New Bookmark or via the Browser panel.

## 13.4 Colour Ramps

To add additional colour ramps to the default option use the “Create New Colour Ramp” from the drop down box to the right of the Color Ramp selection box,. The preset colour ramps are shown in the “Color Ramp” dialog box and I recommend the Catalog: cpt-city option which will display the next dialog box.

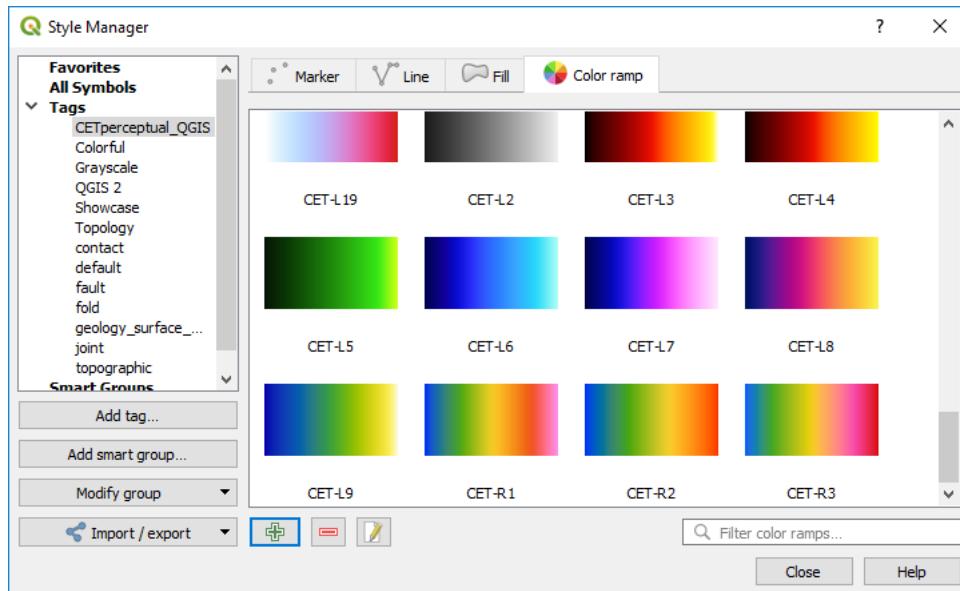
There are many different groups to select from, but I prefer the QGIS tab, and the continuous colour bands, e.g. “bgyr”.





New colour ramps can also be imported via the Style Manager dialog box.

The Centre for Exploration Targeting (CET) in Perth have developed colour ramps that are better for visual perception (see [this link](#)). They are available in a QGIS xml format that can be imported via the Style Manager. These styles can then be accessed as favourites. My preference for data grids such as magnetics is to use the CET-R1 colour ramp.



## 13.5 Colour Selection

To assist in selecting colours for maps, you can visit the [ColorBrewer website](#) where rgb, hex and cymk values of a huge variety of colour options can be viewed and selected as required.

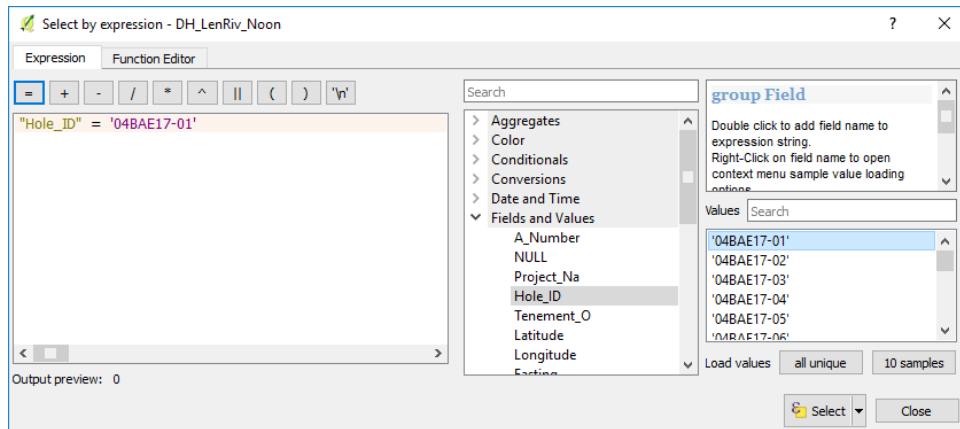
## 13.6 Data Searching

When searching large datasets, a number of options can be used. Spatial searches can be done in your map window but text searches are best done via the Expression form.

Highlight the layer in the Layers panel, bring up its attribute table and click on the “Select Features Using an Expression” button.

DH_LenRiv_Noon :: Features total: 17535, filtered: 17535, selected: 0									
	A_Number	Hole_ID	Latitude	Longitude	Easting	Northing	MGA_Zone	Max_depth	Hole_type
1	59481.00000000...	DVDH800	-17.4713395183...	124.6855963214...	678987.0000000...	8067511.000000...	51.00000000000...		AC 21
2	59481.00000000...	DVDH803	-17.4726948067...	124.6856087811...	678987.0000000...	8067361.000000...	51.00000000000...		AC 21
3	59481.00000000...	BLDH3055	-17.4798308999...	124.6858815523...	679009.0000000...	8066571.000000...	51.00000000000...		AC 21

This will bring up the expression editor window. Click on the central panel to select the field to search in, then press “all unique” in the lower right hand side of the dialog box to show all the entries in this field. You can filter by entering values into the “Values” window. Double click the field name to enter it into the left hand panel. Use the function button to add a function, e.g. “=” and then double click on the value to search for in the right hand panel. Hit select to run the query.



Go to the attribute table and select the “Move selection to top” of the table. This may take a little while in large datasets but it will display the selected record(s) at the top of the table and highlight them.

DH_LenRiv_Noon :: Features total: 17535, filtered: 17535, selected: 1									
	A_Number	Hole_ID	Latitude	Longitude	Easting	Northing	MGA_Zone	Max_depth	Hole_type
1	70092.00000000	04BAE17-01	-17.445249038...	124.6597496225...	709200.000000...	8070190.000000...	51.000000000000...		LD
2	59481.00000000	DVDH800	-17.4713395183...	124.6855963214...	678987.000000...	8067511.000000...	51.000000000000...		AC
3	59481.00000000	DVDH803	-17.4726948067...	124.6856087811...	678987.000000...	8067361.000000...	51.000000000000...		AC
4	59481.00000000	BLDH3055	-17.4798308999...	124.6858815523...	679009.000000...	8066571.000000...	51.000000000000...		AC
5	59481.00000000	BLDH3056	-17.4800567811...	124.6858836303...	679009.000000...	8066546.000000...	51.000000000000...		AC

To show these on the map, select the “Pan map to selected rows” icon and the map will pan to the area of the selected features.

DH_LenRiv_Noon :: Features total: 17535, filtered: 17535, selected: 1									
	A_Number	Hole_ID	Latitude	Longitude	Easting	Northing	MGA_Zone	Max_depth	Hole_type
1	70092.00000000	04BAE17-01	-17.445249038...	124.6597496225...	709200.000000...	8070190.000000...	51.000000000000...		LD
2	59481.00000000	DVDH800	-17.4713395183...	124.6855963214...	678987.000000...	8067511.000000...	51.000000000000...		AC
3	59481.00000000	DVDH803	-17.4726948067...	124.6856087811...	678987.000000...	8067361.000000...	51.000000000000...		AC
4	59481.00000000	BLDH3055	-17.4798308999...	124.6858815523...	679009.000000...	8066571.000000...	51.000000000000...		AC
5	59481.00000000	BLDH3056	-17.4800567811...	124.6858836303...	679009.000000...	8066546.000000...	51.000000000000...		AC

## 13.7 Digitising Toolbar (Plugin)

Every tool is activated as soon as the active layer is of an appropriate type and in edit mode. Keep in mind that some tools need that the current layer’s CRS matches the project CRS.

As a general rule of thumb your editing layer’s CRS and the project’s CRS should match. It makes life easier. If you need results in a different CRS, transform the layer after you have finished your digitizing session.

All edits can be undone/redone using QGIS’ standard undo/redo capabilities.

### 13.7.1 Split multipart to single part

applies to: *MultiPoint, MultiLine and MultiPolygon layer*

1. batch mode: The selected multi-part features in the active layer are split into single part and added to the layer as new features, keeping the attributes of the original (multi-part) feature.
2. interactive mode: click on any multi-part feature. The feature will be split into single parts which are added to the layer as new features, keeping the attributes of the original (multi-part) feature.

### 13.7.2 Split off one part and add it as new feature

*applies to: MultiPoint, MultiLine and MultiPolygon layer*

Click on any part of a multi-part feature. The part will be deleted from the original feature and added as a new (single-part) feature to the layer keeping the attributes of its parent (multi-part) feature.

### 13.7.3 Split features

*applies to: Line, MultiLine, Polygon and MultiPolygon layers*

Works exactly like Split Features tool in QGIS' Advanced Digitizing Toolbar when applied to non-multi features. When applied to multi features the user is asked via a dialog (see below) which of the newly created geometries (fraction of a part) should become the new feature. The other fraction stays as part within the original multi feature. Thus it replaces QGIS' Split Parts, too, which is of limited use, because its application results in an invalid geometry if the split-off part is not edited any further. The dialog shown when splitting multi-part features has four buttons:

1. Cancel aborts the current splitting operation and leaves all features untouched.
2. No to All aborts the splitting of the current feature and leaves it untouched.
3. No leaves the currently highlighted fraction in the multi-part feature.
4. Yes accepts the currently highlighted fraction for becoming the new feature.

### 13.7.4 Merge selected features

*applies to: any layer with a primary key field, i.e. a database layer*

This works as the Merge selected features button in QGIS Core, except that Core's Merge selected features deletes all selected features and then inserts a new feature. DigitizingTools' method offers the user to choose which feature to keep by choosing its primary key value. This feature's geometry is updated with the combined geometry of all selected features, while all other selected features are deleted. This feature will be removed once #13490 is closed and implemented.

### 13.7.5 Exchange attributes between selected features

*applies to: any vector layer*

Exchanges the attributes between two selected features of the active layer. Reasoning: when splitting features in a layer coming from a database provider the user can thus control which feature is going to keep the primary key value (important for related tables).

### 13.7.6 Cut with polygon from another layer

*applies to: line and polygon layer (multi or single part)*

Choose another layer whose selected features are used like a cookie cutter on the active layer. Everything that falls under the cutter feature(s) is erased. If a selection exists in the active layer only selected features are cut. In case a feature would completely disappear, a message is issued to the user, asking if this feature should be deleted.

### 13.7.7 Clip with polygon from another layer

*applies to: line and polygon layer (multi or single part)*

Choose another layer whose selected feature is used like a cookie cutter on the active layer. Everything that falls under this feature will survive, everything outside will be erased. If a selection exists in the active layer only selected features will be clipped.

### 13.7.8 Fill ring

*applies to: polygon layer (multi or single part)*

Fill rings (islands) in polygons with new features. This tool has two modes:

1. batch mode: all rings in the selected features are filled with new features. The attribute set for all features is identical and can be entered once if form popup after feature creation is not suppressed.
2. interactive mode: click into any the ring. A new feature is snuggled into the ring.

### 13.7.9 Fill gap

*applies to: polygon layer (multi or single part)*

Fill gaps between the selected polygons of the active layer with new features. The algorithm has to union all selected features first, thus the selection is necessary to speed up the process, especially if the layer contains many features. This tool has two modes:

1. batch mode: all gaps between the selected features are filled with new features. The attribute set for all features is identical and can be entered once if form popup after feature creation is not suppressed.
2. interactive mode: click into the gap to be filled. A new feature is snuggled into the gap.

### 13.7.10 Fill gap (all visible layers)

*applies to: polygon layer (multi or single part)*

Fill gaps between the polygons of all visible layers with a new feature: click into the gap to be filled. A new feature is snuggled into the gap.

### 13.7.11 Split selected features with selected line from another layer

*applies to: line and polygon layer (multi or single part)*

Splits all selected features of the active layer with the selected line feature of another layer. The splitting creates new features (not multi features). Each new feature resulting from being split retains its original attributes.

### 13.7.12 Flip line

*applies to: line layer (multi or single part; does not make too much sense with multi part, though)*

Flip the direction of a line, i.e. reverse the node order within the line. This tool has two modes:

1. batch mode: all selected lines are flipped.
2. interactive mode: click any line feature to have it flipped (successful clicking depends on layer's snap settings).

## 13.8 Favourites

To add a directory as a Favourite for quick access, right click on the “Favourites” item in the Browser panel, then add directory. The favourite directory will then make it much quicker to access commonly used files.

## 13.9 Profile Tool

This plug-in allows the user to put a line across a grid and obtain a profile along the line. Note there will be a new addition to the View menu in version 3.26 where the Elevation data can be viewed in profile direct within QGIS.

## 13.10 Points to Lines and Polygons

To create a line or polygon from a list of coordinates, for example an excel spreadsheet with tenement corners, use the Processing Toolbox > SAGA > Vector Line Tools > Convert Points to Lines and/or Convert Lines to Polygons.

## 13.11 QPackage

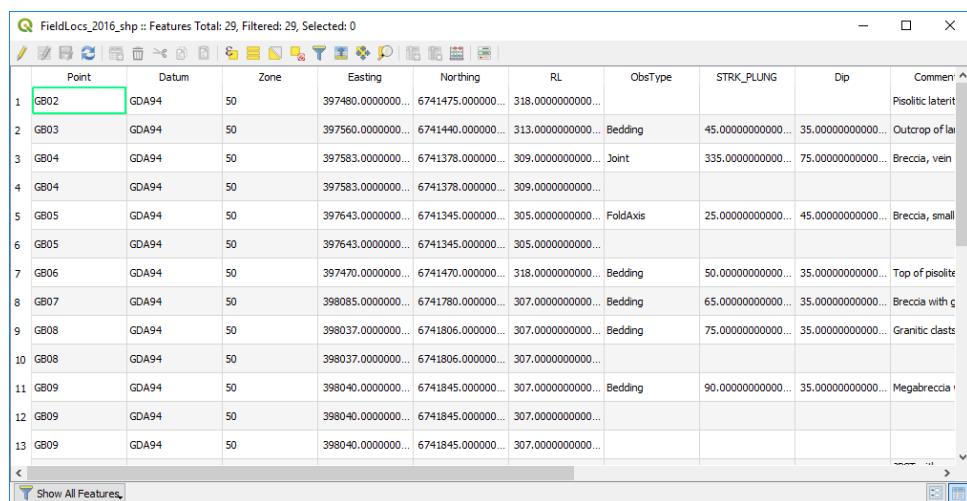
The QPackage plug-in allows the user to create a project file with an associated folder holding all the relevant layers for that project. Note that this will only copy vector files.

## 13.12 Quick Rectangles, Circles, Ellipse Shapes

The Shape Digitising toolbar allows the creation of vector shapes, e.g. rectangle and circles.

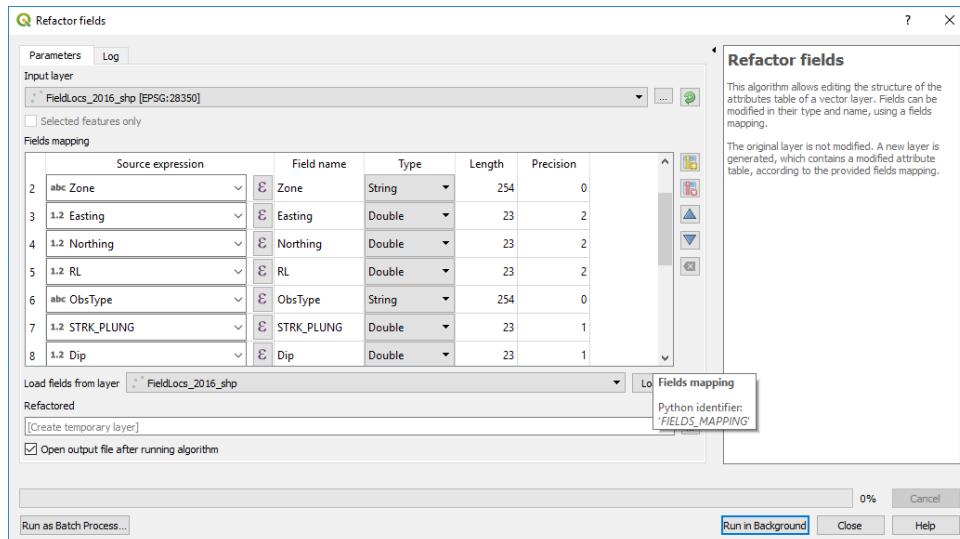
## 13.13 Refactor Fields

The Refactor Fields algorithm allow the modification of a table’s attributes. Be careful using this!



	Point	Datum	Zone	Easting	Northing	RL	ObsType	STRK_PLUNG	Dip	Comments
1	GB02	GDA94	50	397480.000000...	6741475.000000...	318.0000000000...				Pisolitic laterit
2	GB03	GDA94	50	397560.000000...	6741440.000000...	313.0000000000...	Bedding	45.0000000000...	35.0000000000...	Outcrop of la
3	GB04	GDA94	50	397583.000000...	6741378.000000...	309.0000000000...	Joint	335.0000000000...	75.0000000000...	Breccia, vein
4	GB04	GDA94	50	397583.000000...	6741378.000000...	309.0000000000...				
5	GB05	GDA94	50	397643.000000...	6741345.000000...	305.0000000000...	FoldAxis	25.0000000000...	45.0000000000...	Breccia, small
6	GB05	GDA94	50	397643.000000...	6741345.000000...	305.0000000000...				
7	GB06	GDA94	50	397470.000000...	6741470.000000...	318.0000000000...	Bedding	50.0000000000...	35.0000000000...	Top of pisolit
8	GB07	GDA94	50	398085.000000...	6741780.000000...	307.0000000000...	Bedding	65.0000000000...	35.0000000000...	Breccia with g
9	GB08	GDA94	50	398037.000000...	6741806.000000...	307.0000000000...	Bedding	75.0000000000...	35.0000000000...	Granitic clasts
10	GB08	GDA94	50	398037.000000...	6741806.000000...	307.0000000000...				
11	GB09	GDA94	50	398040.000000...	6741845.000000...	307.0000000000...	Bedding	90.0000000000...	35.0000000000...	Megabreccia
12	GB09	GDA94	50	398040.000000...	6741845.000000...	307.0000000000...				
13	GB09	GDA94	50	398040.000000...	6741845.000000...	307.0000000000...				

Note the fields with way too many decimals. These can be fixed using the Processing Toolbox > Vector General > Refactor Fields.

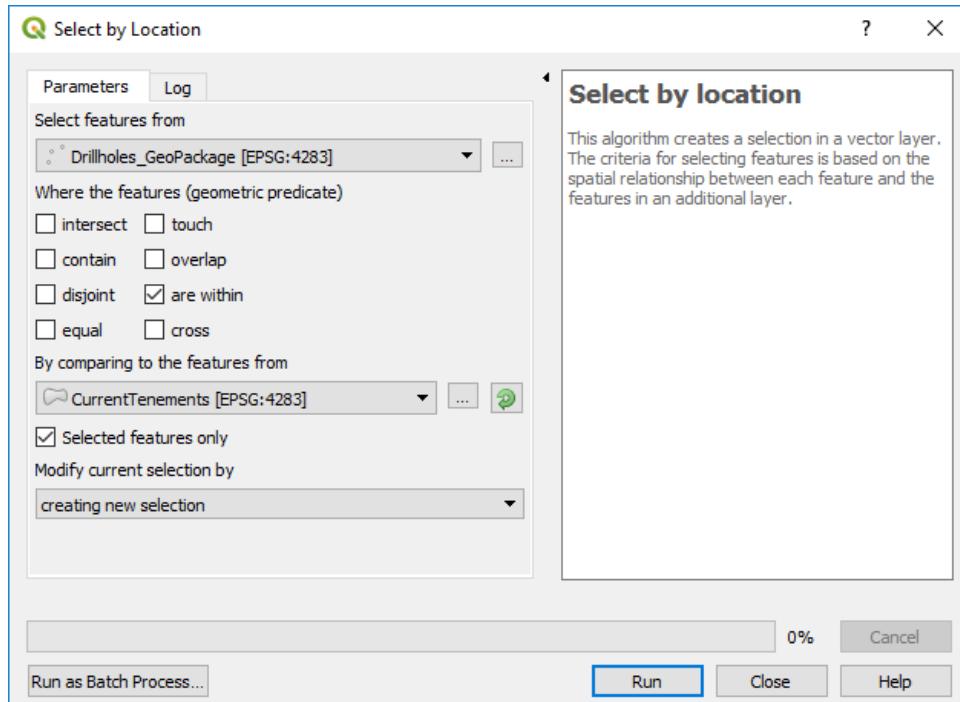


Field names, types and other info can be changed in this window.

## 13.14 Selecting Drill Holes by Tenement

To select drill holes in a tenement, simply highlight the drill hole layer in the Layers panel, then in the top menu bar choose, select Features by polygon, then right click on the polygon you want to use to select the drill holes, the select layer (e.g. tenements layer) will be listed, just select that layer and the holes will selected for that tenement. Note this may not work with layers in different projections.

The other method that can be used is the Processing Toolbox > Vector Selection > Select by Location algorithm.



If you hold the “Alt” key while making a selection QGIS, it switches from an “intersects” type selection to a “contains” selection mode. (This also works while holding the shift modifier to add to a selection, or ctrl to subtract from a selection!).

## 13.15 Spatialite Databases

A Spatialite database is a simple, single file database structure that can hold very large files but with the advantage that the data is spatially referenced. The spatial referencing allows the data to be quickly displayed when panning across a map. This is very useful for data such as the 250k vector data (from GA) for Australia or the large GSWA open file drill hole database.

The use of Spatialite database files can rapidly increase the speed of accessing large data sets. As an example, the entire 1:250 000 Geoscience Australia Australia-wide topographic vector data in zipped shapefile format is 1.01 Gb in size (GA file 64058.zip) and comprises many layers including road, rivers, etc. This file can be loaded into a Spatialite database file of about 3 Gb, but although a large file, the data is spatially indexed, and re-drawing of the data is very fast when panning from area to area.

Another spatialite option is to use the new GeoPackage file format which can store large datasets comprising vector, raster and non-spatial data.

## 13.16 Extracting Colour Styling Information from MapInfo Files

Colour polygon information can be extracted from MapInfo files using an RGB extraction routine in the MapInfo-Discover module.

# CHAPTER 14

## DRONE MAPPING IN QGIS

The use of drones is now becoming commonplace for mapping, particularly with the inexpensive drones now available on the market. Drone derived orthophoto maps, digital terrain models, digital surface models and point clouds can be read directly into QGIS.

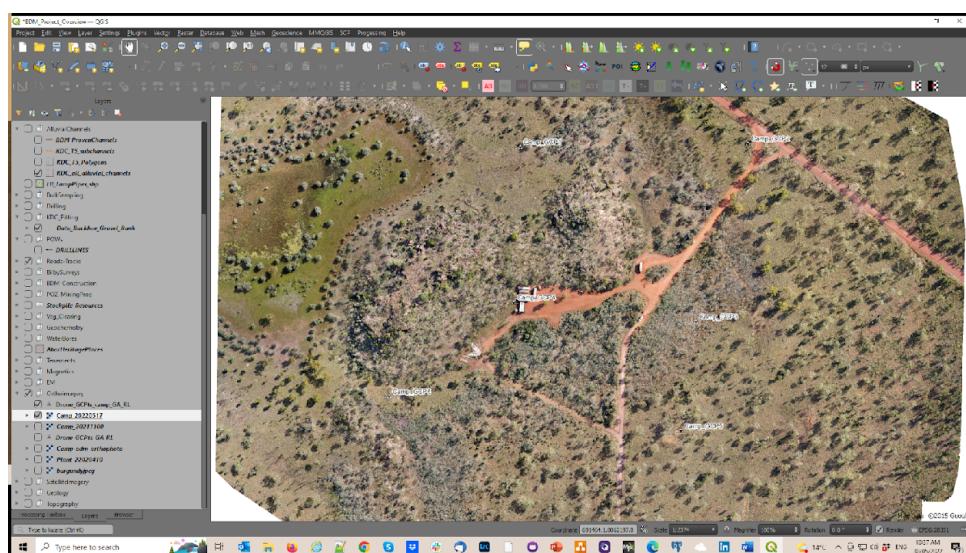


Fig. 1: An example of an orthophoto created with the DJI Mini 2 and 6 ground control points.

I have a DJI Mini 2 with which I have been experimenting with lately to create orthophoto maps for various projects and found it particularly useful when documenting mineral exploration activities, environmental disturbance and/or construction progress. In my experience I have been able to get accuracies of the order of 5 m with the built-in drone GPS and this can be improved with ground control points located by handheld gps. Greater accuracies will be achieved if the ground control points are accurately surveyed with 10 cm being achievable. In many cases 2-3 m accuracy will be suffice. Oblique aerial views are also very useful to document progress and for public relations images.

It is important to understand your drone and be a capable drone pilot before trying any drone mapping. Note also you will require government accreditation, e.g. via the Civil Aviation and Safety Authority (CASA) in Australia, before you can fly your drone. Please check your local regulations.

There are numerous YouTube videos that explain the map making and drone process. I have found with my DJI Mini 2, I can fly at 120 m agl (above ground level, maximum allowed) with a 50 m line spacing and that will allow the creation of an orthophoto with a 4 cm per pixel ground resolution and sufficient photo overlap to allow good orthophoto creation.

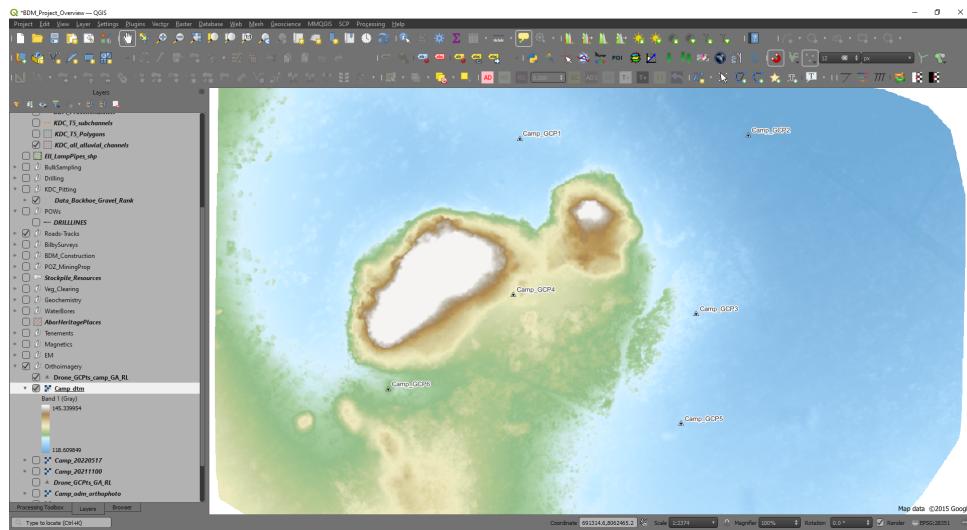


Fig. 2: Example of digital terrain model (DTM) from drone survey.

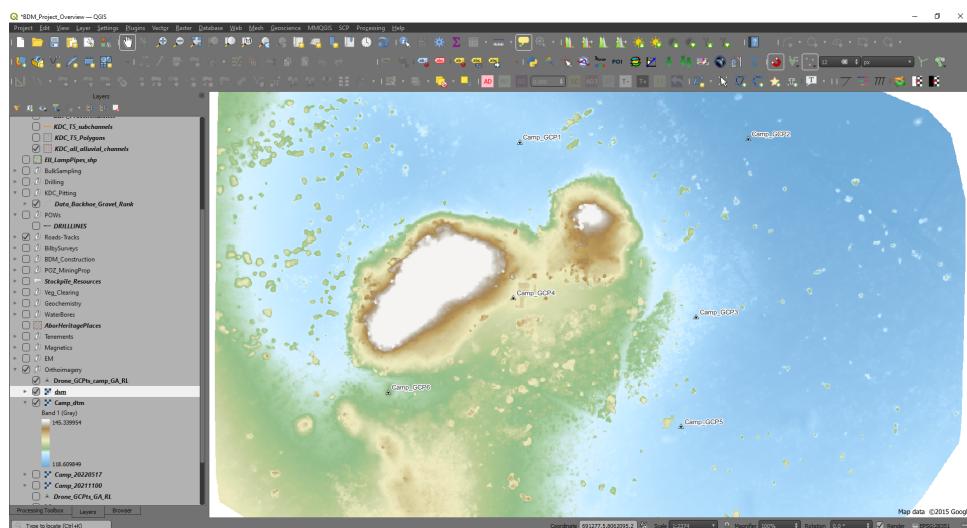


Fig. 3: Example of digital surface model (DSM).

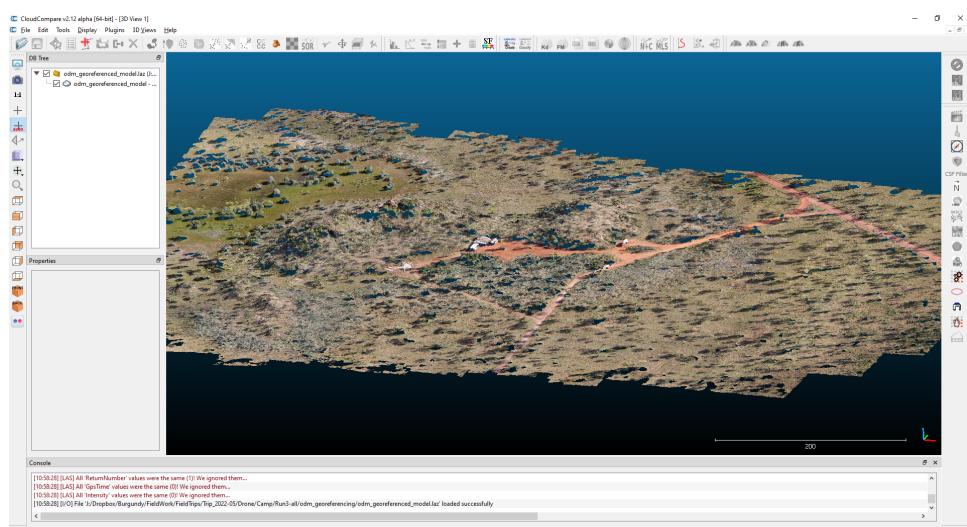


Fig. 4: Example of a point cloud for the above examples using CloudCompare program.

My workflow comprises whether to mark out ground control points, at least 6 to cover a rectangular area, if moderate accuracy is required. Ground control points need to be clearly visible from the air and I have been trialling 4 x 30 cm square ceramic tiles, two white and two black, to create a checkerboard pattern which are clearly visible from 120 m agl. These tiles will also be resistant to the weather and the GCP's should be useable over a number of years.

Note that if you have surveyed mining tenements, for example a mining lease boundary, these will have been accurately surveyed and as such are useful ground control points.



Fig. 5: Example of a ground control point using 4 x 30 cm ceramic tiles.

I use three software applications; DJIFlightPlanner, to create pre-programmed flight missions, the Litchi app for my smartphone, and WebODM to carry out the photogrammetry calculations to create orthophotos, DTM, DSM and point clouds of the collected data. None of these are free but they are low cost.

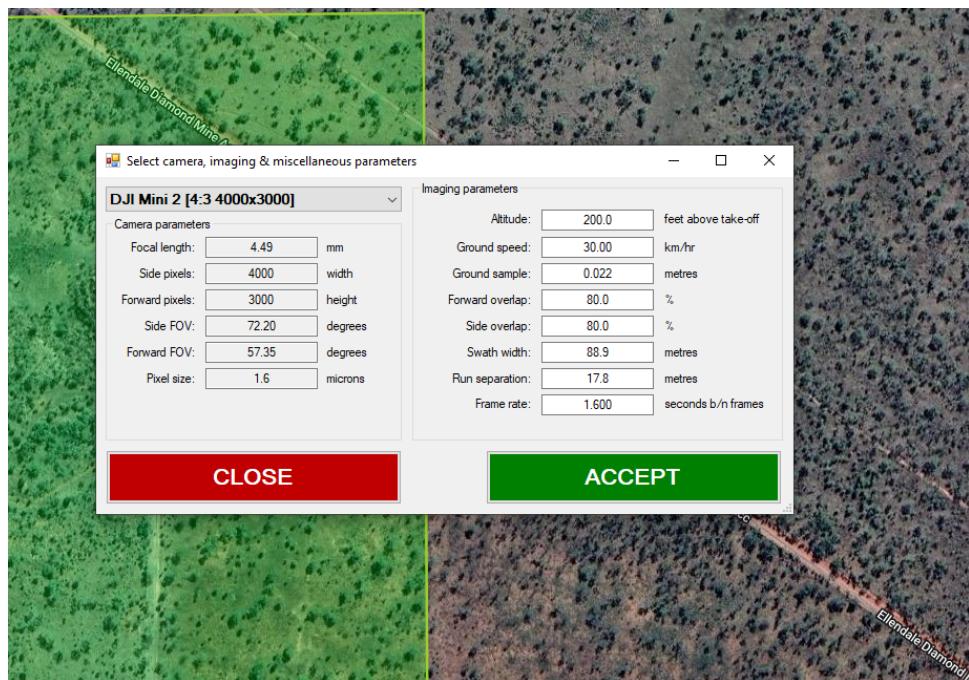
There are a number of flight planning software options available, and these programs create a pre-programmed flight so that the drone knows where to fly, how high and other variable like speed and camera photo intervals. The output from the flight planning software is transferred to the flight controller app - the Litchi app - on your smartphone which will send the flight information to the drone.

Once the photos have been collected, they are checked and then loaded into the photogrammetry program WebODM.

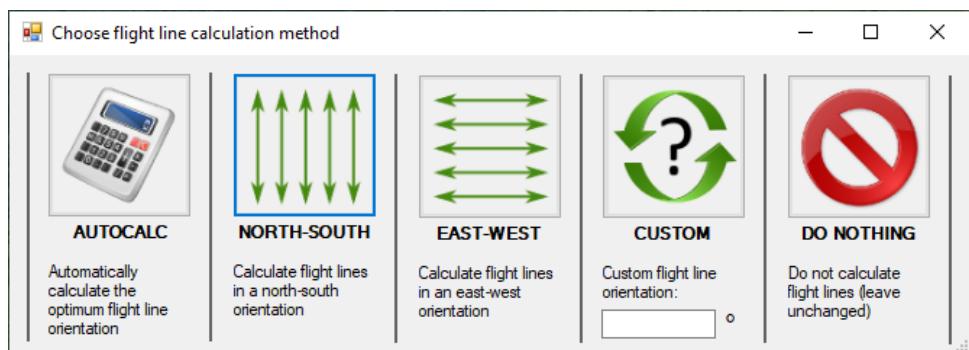
## 14.1 Mission Planning

To plan your drone survey, create a KML (Google Earth) polygon file in QGIS and import this into DJIFlightPlanner. Select your drone camera from the drop-down list on the left and check the suggested flight parameters in the right-hand side of the pop-up box.

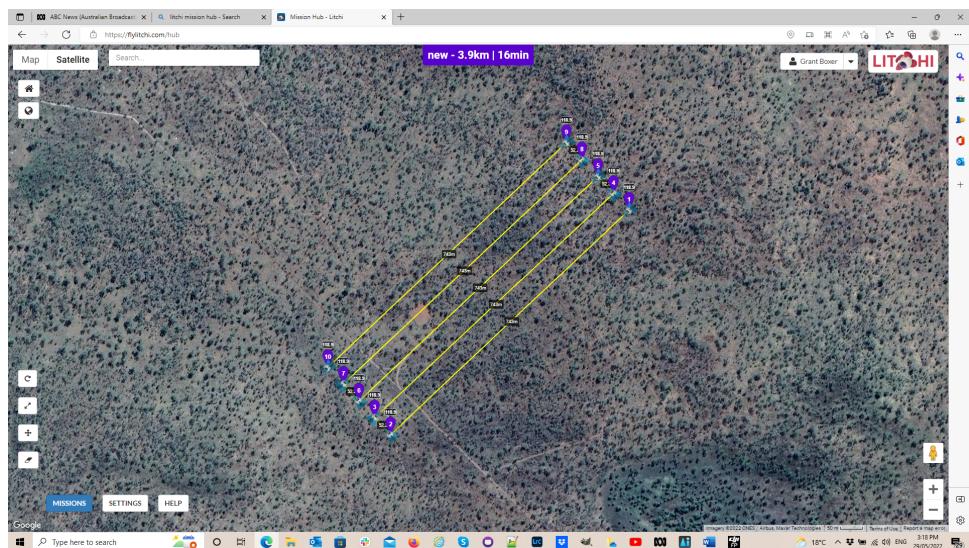
I would typically adjust the “Altitude” to my preferred altitude of 120 m (roughly 390 ft) and a ground speed of 20 kph, which allows a photo interval 7 seconds to give a suitable photo overlap (70%).



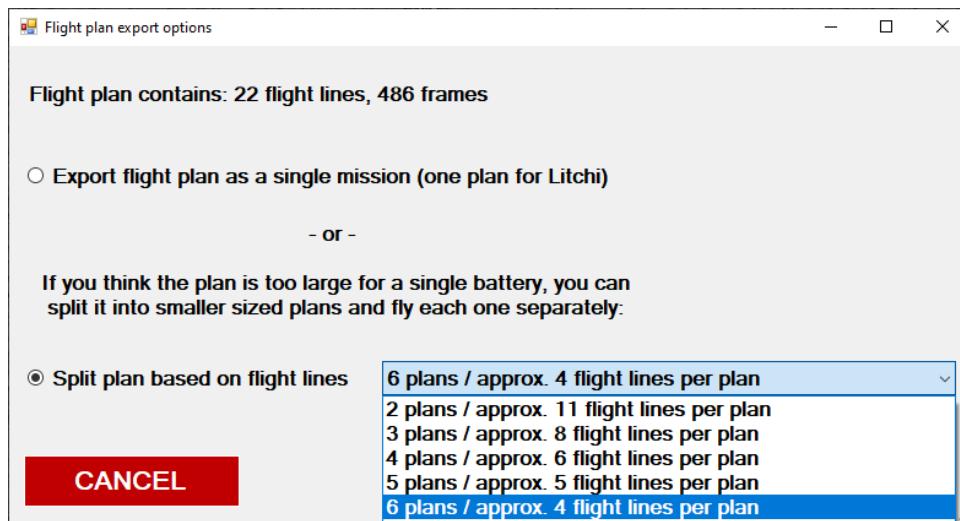
The flight line direction can then be selected.



The flight lines and photo points are then calculated.



These flight lines are then exported using the “Export” to “CSV for Litchi” option. I would then create a time-based flight and use the split the flight plan into 4 flights per plan.

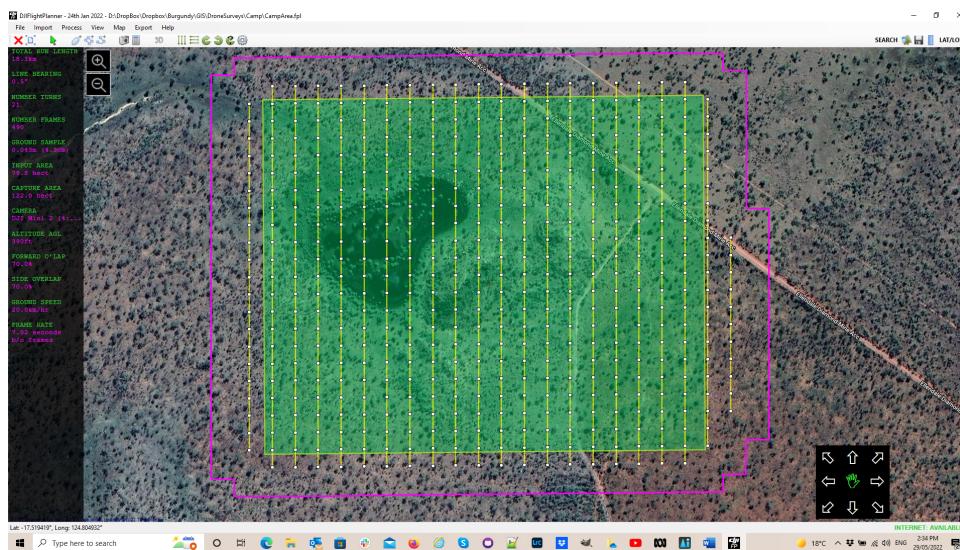


The reason for multiple plans is that I know the Mini 2 batteries have an endurance (flight time) of about 20 minutes, so I design each plan to have a flight time of around 15 minute to allow for drone return to home and any unforeseen headwinds. The battery will be replaced after each flight and with 6 batteries, this allows me to fly six flight plans before I need to recharge my drone batteries.

## 14.2 Creating the Flight Plan

The output from the DJIFlight Planner, the csv file, is imported using the [Litchi Mission Hub web portal](#) and the Mission > Import option.

Within the Litchi Mission Hub, you can fine tune what happens at each waypoint, e.g. the height and photo interval. The return to home (RTH) option is set in the Litchi app on your smartphone so at the end of each flight plan, the drone returns to home. Note this window displays the length of the flight plan and the flight time.



When all the details are correct this is saved to the mission hub and can be downloaded to your smartphone when you next open up the Litchi app (making sure you do this while you have an internet connection). The background Google Earth image will be cached in your phone if you open up each flight plan while you have an internet connection.

## 14.3 Flying your Mission

Before you fly, make sure all your batteries are charged and the weather is suitable. Check for any helicopter activity in the area before you fly. After take-off, check all your aircraft settings are correct, such as photo type (single, timed image, 3000x4000 aspect for DJI Mini 2). Fly your missions.

## 14.4 Processing the Images

After collecting the photos and downloading them to your computer, check the photos and remove those that are not necessary, like those collected during ferry trips etc. Identify the images with the ground control points (GCP) so they can be used in the creation of the ground control point file. GCP's will usually be identified in about 4 images for each GCP and this is required for WebODM to be able to rectify the orthophoto.

The orthophoto above was created using WebODM from a collection of 266 images and a ground control point file. Processing on my laptop (64 Gb RAM, Core i7 processor) took about 6 hours, so I usually run it overnight. A desktop PC with a large amounts of RAM and disk space, plus multiple cores may make this processing a little quicker.

The default setting with WebODM will create an orthophoto, a digital surface model (dsm), a digital terrain model (dtm, ground level) and a point cloud.

# CHAPTER 15

## A COMPILATION OF HOW-TO'S

This is a list of processes that hopefully will help the users of QGIS with specific geological-type tasks.

### 15.1 Set Drill Collar RL from a DTM

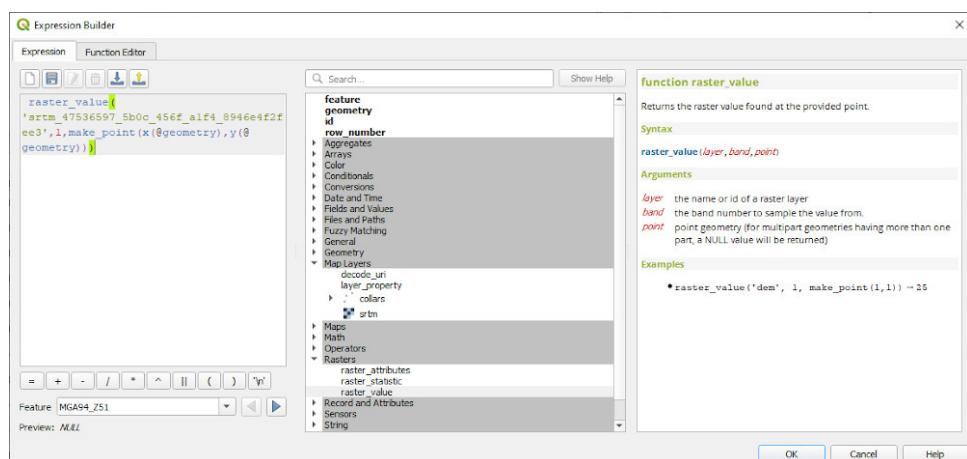
This is one way to populate your drill hole collar file using the values in a digital terrain model of the area.

Ensure your DTM is in the projection of the collar file - reproject if necessary from geographic (Lat/Long) to UTM metres.

You can create a new field or update an existing field - but make sure you have a back-up in case you make an error!

In QGIS, open up your collars table and DTM file (must be a grid not an image). Open the attribute table for the collar file and enable editing. Select the add new field icon and add a new field and set the type to decimal. Then select the new field from the drop down field list and enter in the following into the expression editor.

```
raster_value('DTM layer', 1, make_point(x(@geometry), y(@geometry)))
```



Run update all.

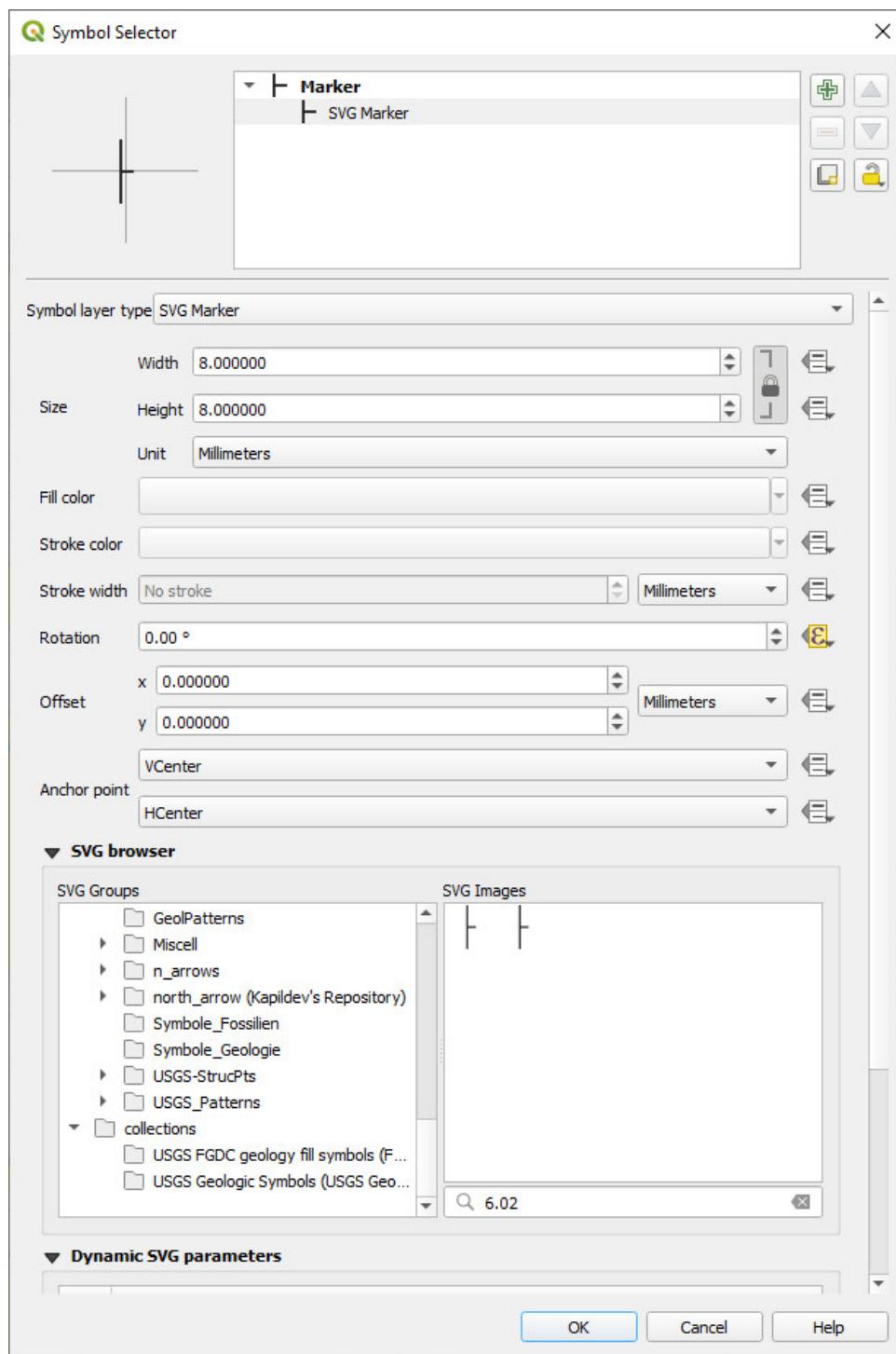
The new field should now be populated with new values extracted from the DTM.

## 15.2 Plot Oriented Structure Symbols

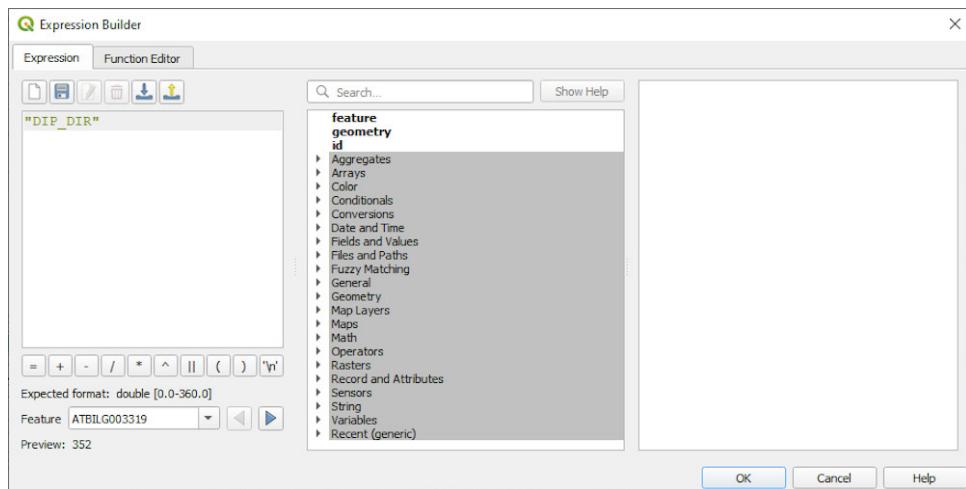
The aim here is to rotate the relevant symbol to represent the orientation of the structure.

The simplest way to do this is to have rotation amount in a data field in your layer, e.g. strike or dip direction, and tell QGIS via the data driven override widget to rotate the symbol by the amount in that rotation field of your layer. Check that the rotation is correct.

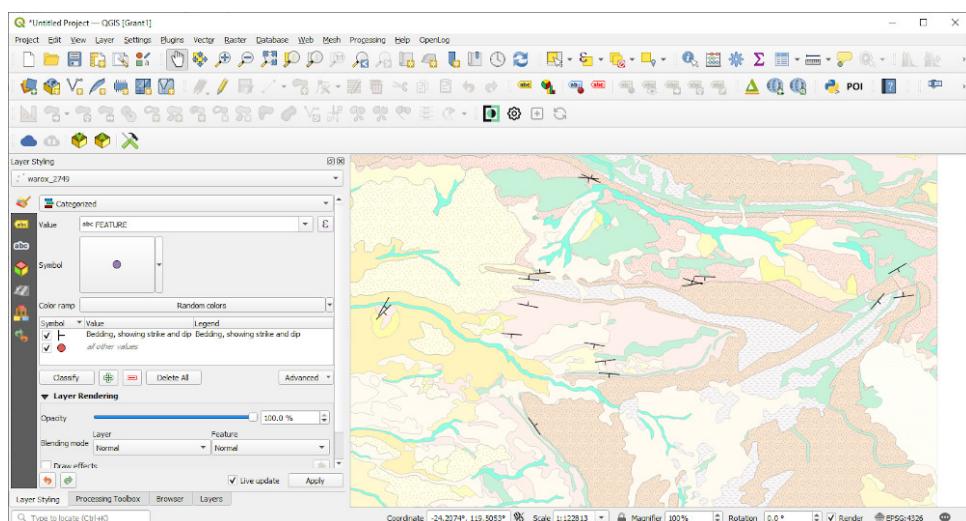
Open the symbol selector dialog by clicking on the structure symbol and then set its symbol.



Select the data driven override widget next to the rotation box and set the field that contains the rotation amount.

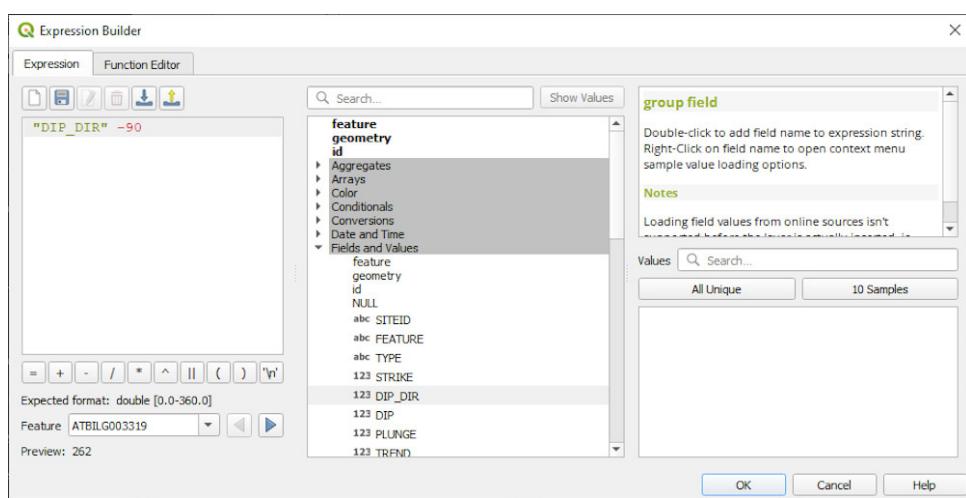


Check that the symbols are correctly oriented.



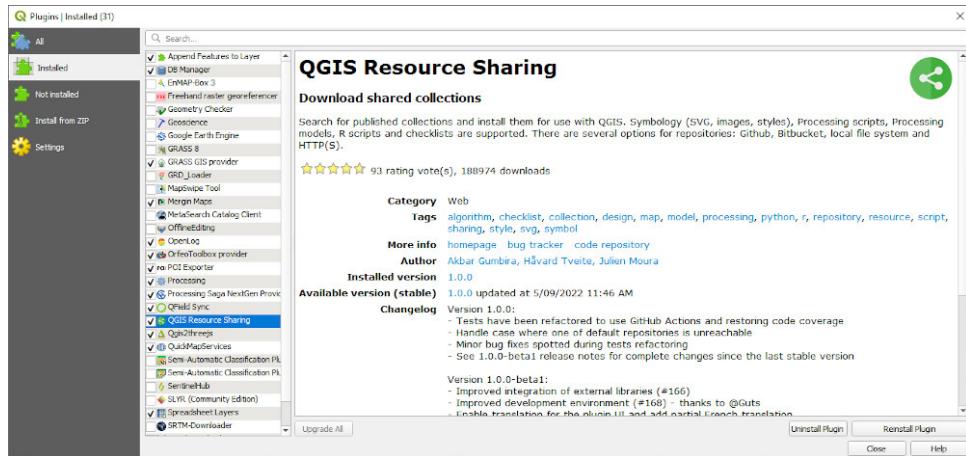
Make sure you know the initial orientation of the symbol, as you might need to subtract 90 degrees for example to get the correct orientation.

Dip\_Direction - 90

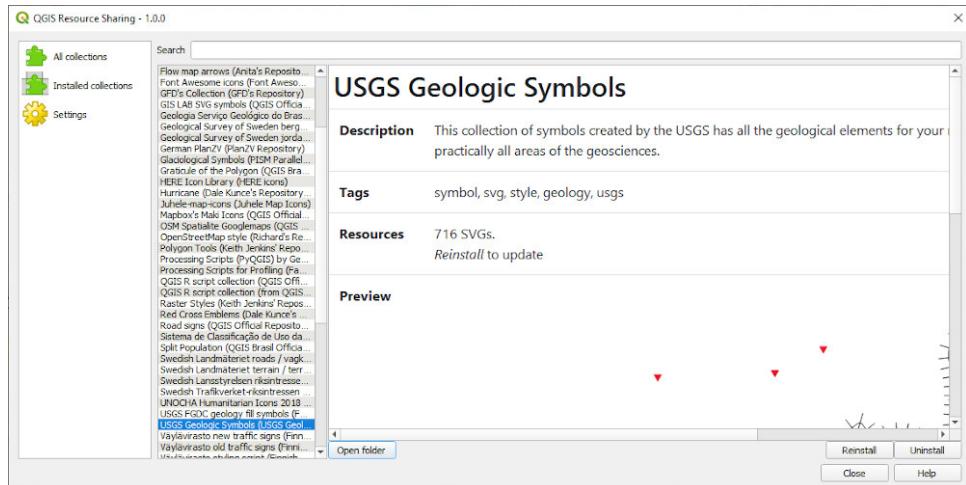


## 15.3 Downloading and Using the USGS Symbols and Pattern Fills

The USGS symbols and patterns can be downloaded from various locations on the internet but the easiest way is via the QGIS Resource Repository plug-in.

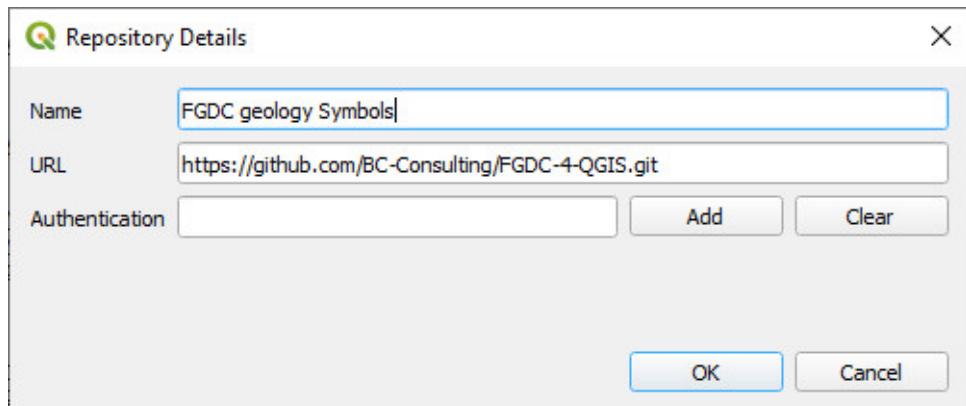


Enable the plug-in and then search for the USGS symbols under the ALL tab.



Install the symbols and these will then be accessible via the symbol selector > SVG > SVG Browser > Collections.

To install the USGS pattern fills, we need to add a new repository to the Resource Sharing plug-in.



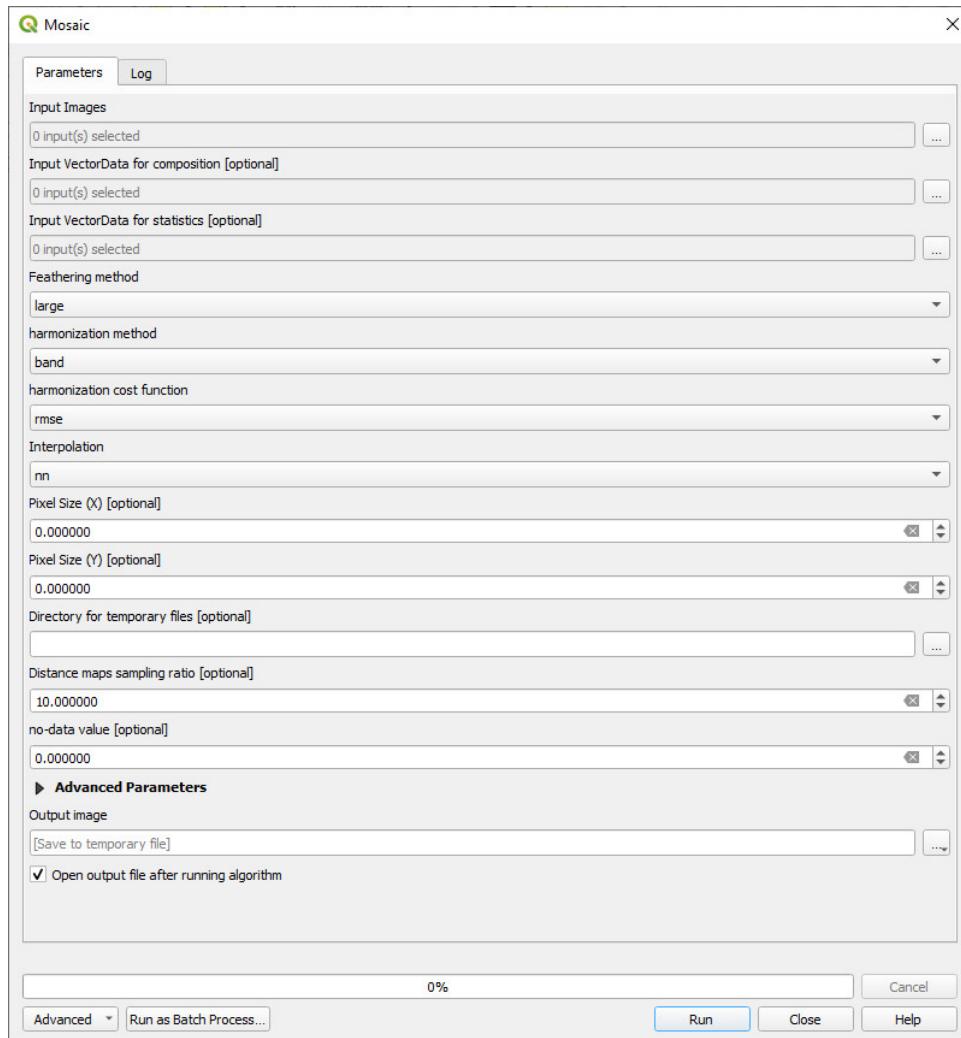
Install the pattern fills and these will then be accessible via the symbol selector > SVG > SVG Browser > Collections.

## 15.4 Merge Adjacent Satellite Image Scenes

When merging adjacent satellite scenes, it is sometime difficult to remove the join lines between images. The best way to solve this is to use the Orfeo Toolbox - installed by defaults but not enabled by default.

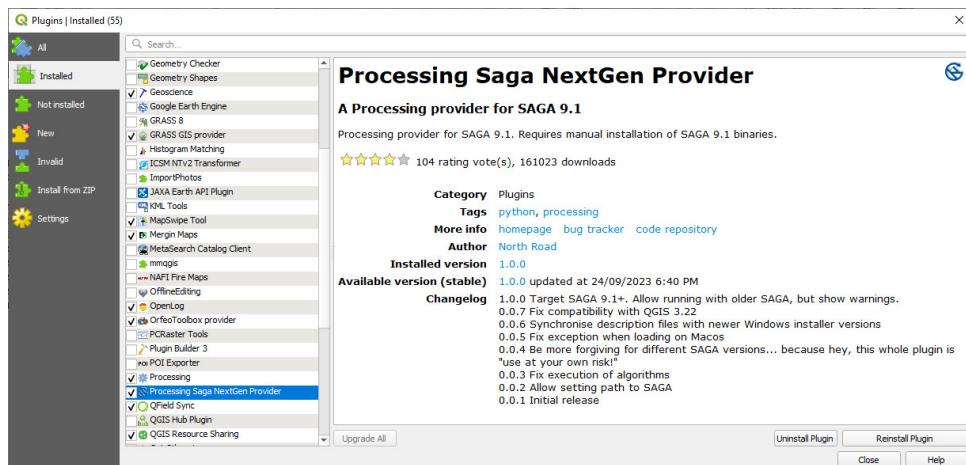
- ▶ OpenLog
- OTB
  - ▶ Calibration
  - ▶ Change Detection
  - ▶ Deprecated
  - ▶ Feature Extraction
  - ▶ Geometry
  - ▶ Hyperspectral
  - ▶ Image Filtering
  - Image Manipulation
    - BandMath
    - BandMathX
    - ColorMapping
    - CompareImages
    - ConcatenateImages
    - DynamicConvert
    - ExtractROI
    - ManageNoData
    - Mosaic
  - MultiResolutionPyramid
  - PixelValue
  - Quicklook
  - ReadImageInfo
  - ResetMargin
  - SplitImage
  - Synthetize
  - TileFusion
  - ZonalStatistics
- ▶ Learning
- ▶ SAR
- ▶ Segmentation
- ▶ Stereo
- ▶ Vector Data Manipulation
- ▶ SAGA Next Gen

The settings may need to be adjusted, but initially try the following settings,  
 select your input files feathering method - Large harmonisation method - band harmonisation cost function -  
 rmse interpolation - nn

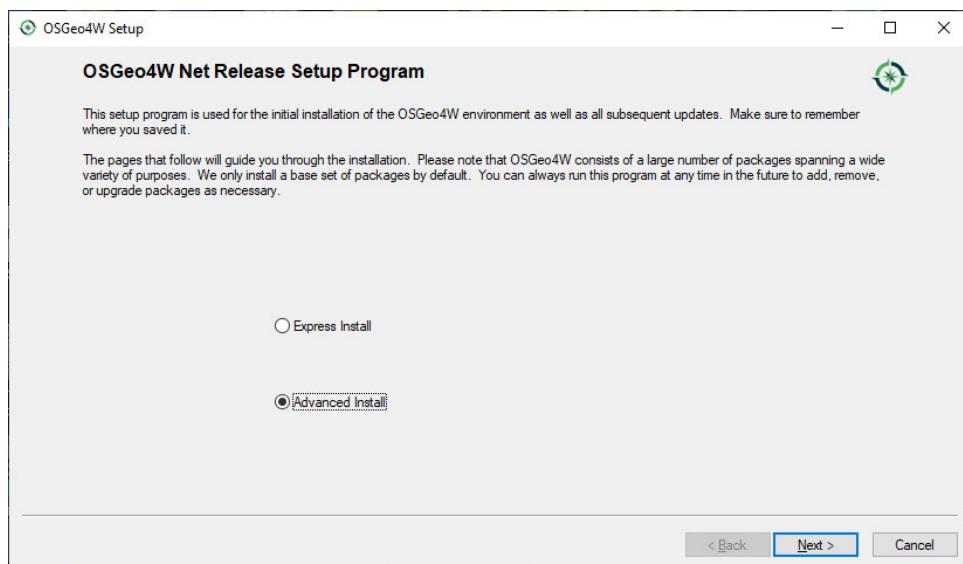


## 15.5 Installing the SAGA Next Gen Provider

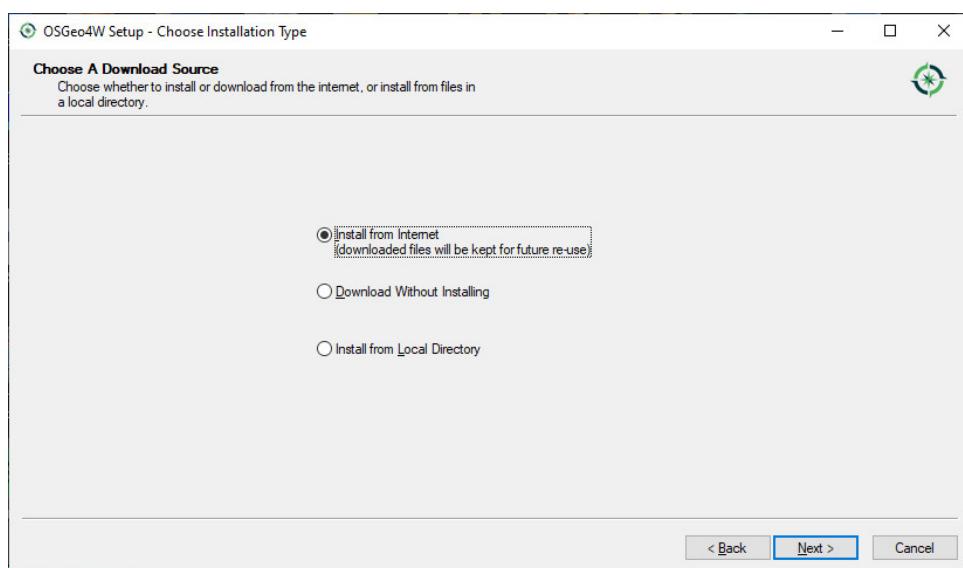
Using the new SAGA Next Gen algorithms requires the installation of additional binary files. To install the SAGA Next Gen, go to the plug-ins manager and select the “Processing Saga Next Gen Provider”.

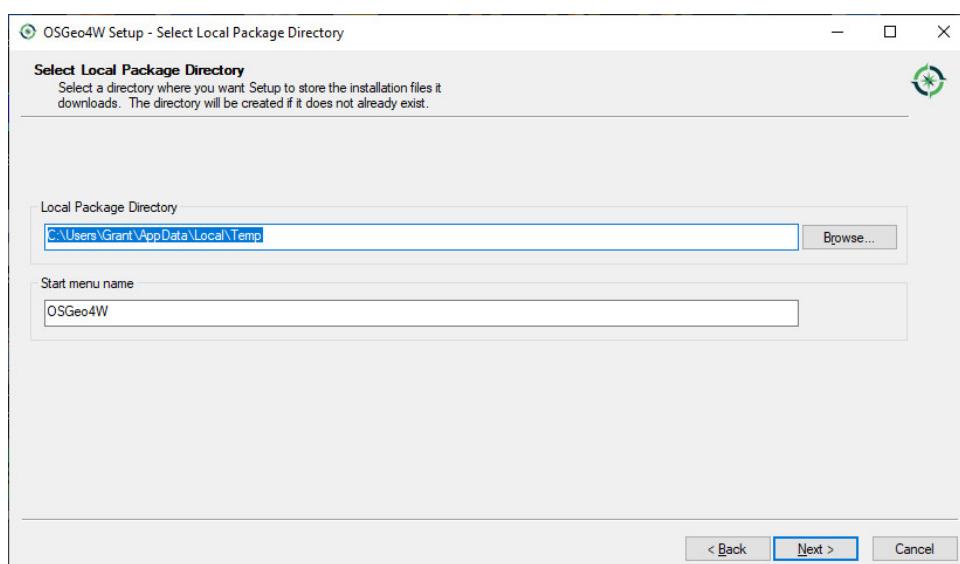
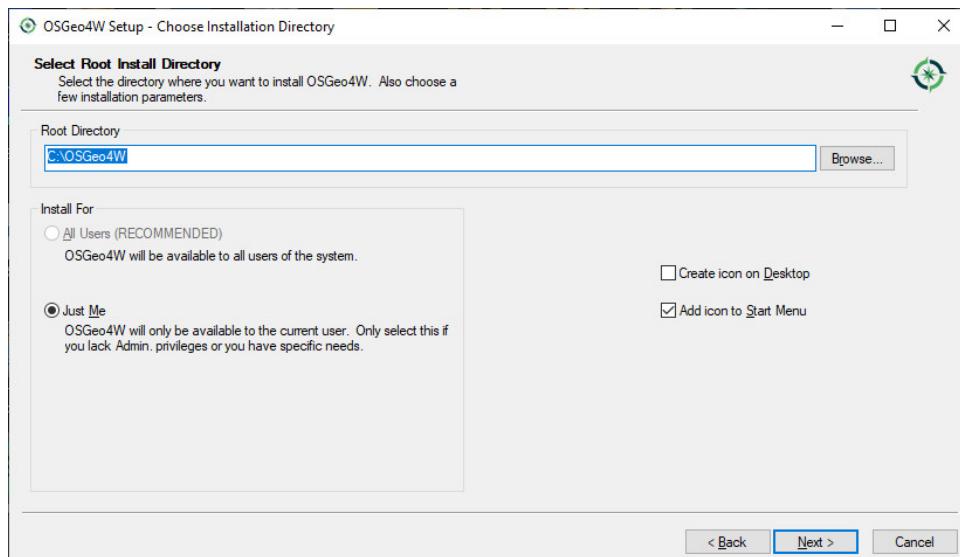


Note that the dialog box indicates that you need to manually install the “SAGA 9.1 binaries” To do this, run the “SetUp” program that was installed with your version of QGIS. This will be either on your desktop or found under the Windows > QGIS x.xx folder.

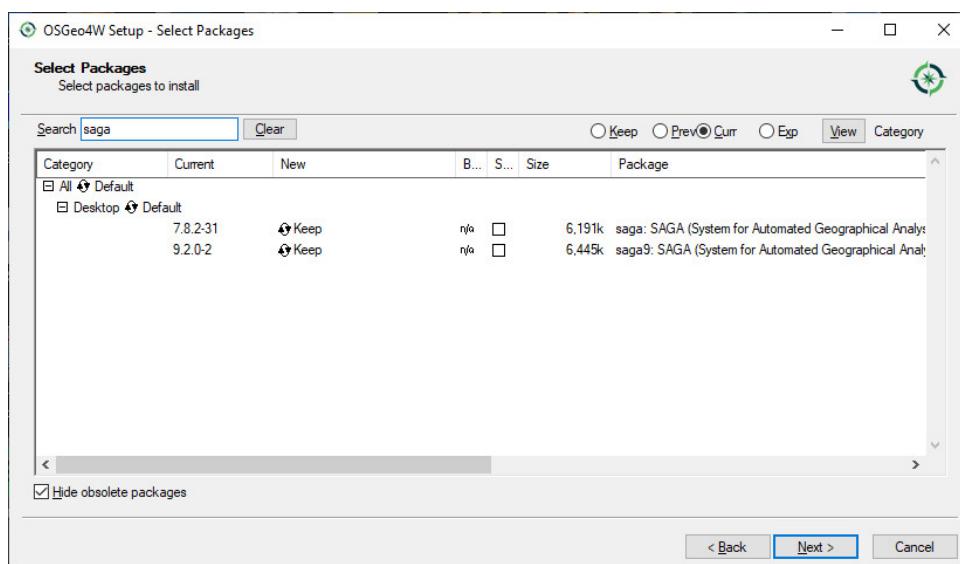


Click through a few screens.

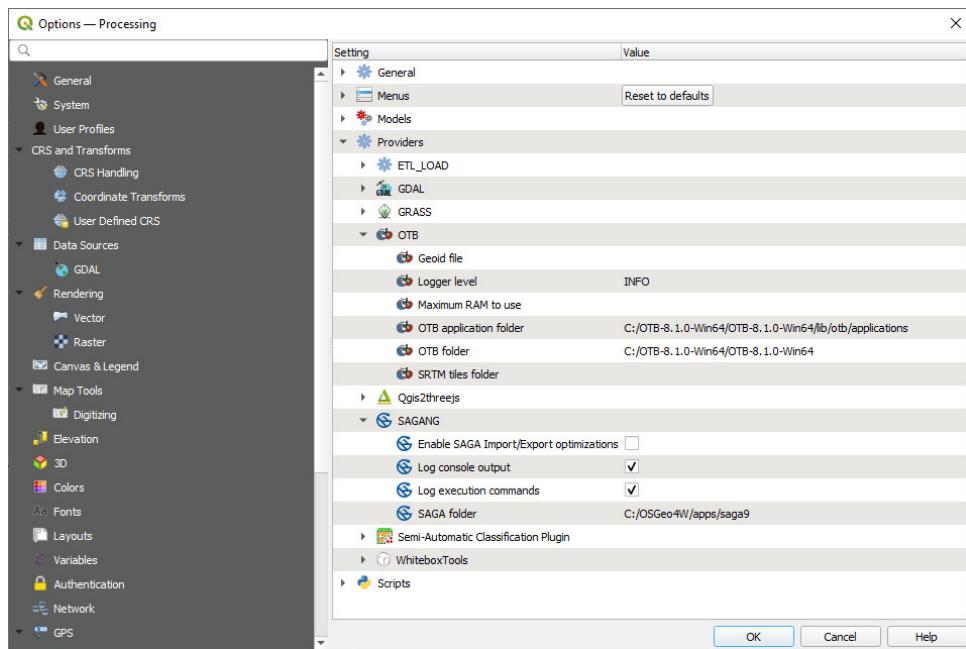




In the screen below, type in “saga” in the search box. You may need to expand the “Desktop” folder.



To enable the SAGA Next Gen algorithms enter the location of the SAGA version 9 folder.



You may need to re-start QGIS to see the new SAGA Next Gen algorithms appear in your Processing Toolbox.

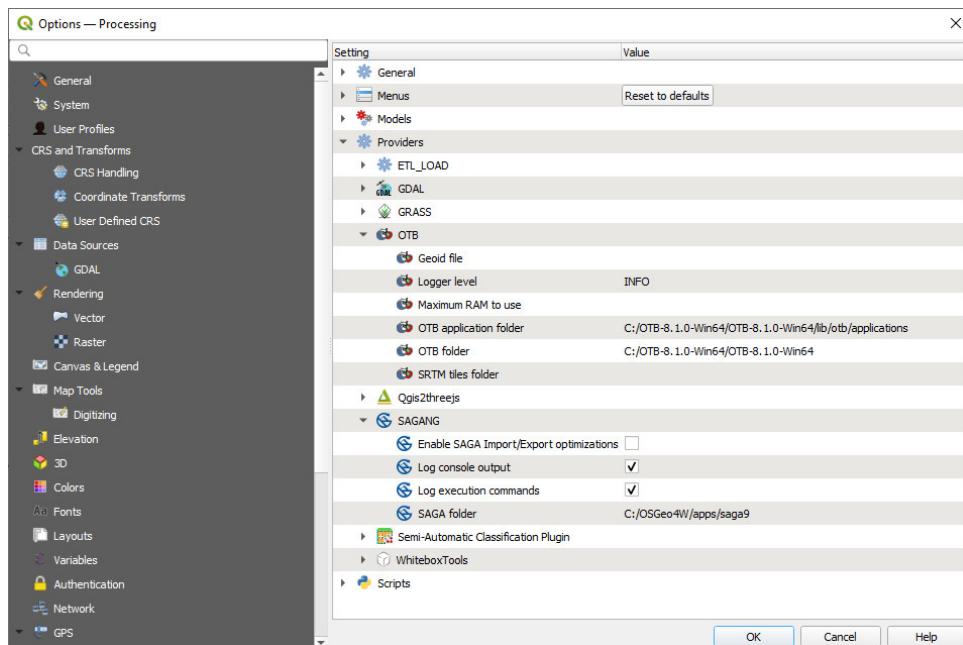
## 15.6 Enabling the Orfeo Toolbox

To install the Orfeo Toolbox, we have to download the binaries from <https://www.orfeo-toolbox.org/download/>.

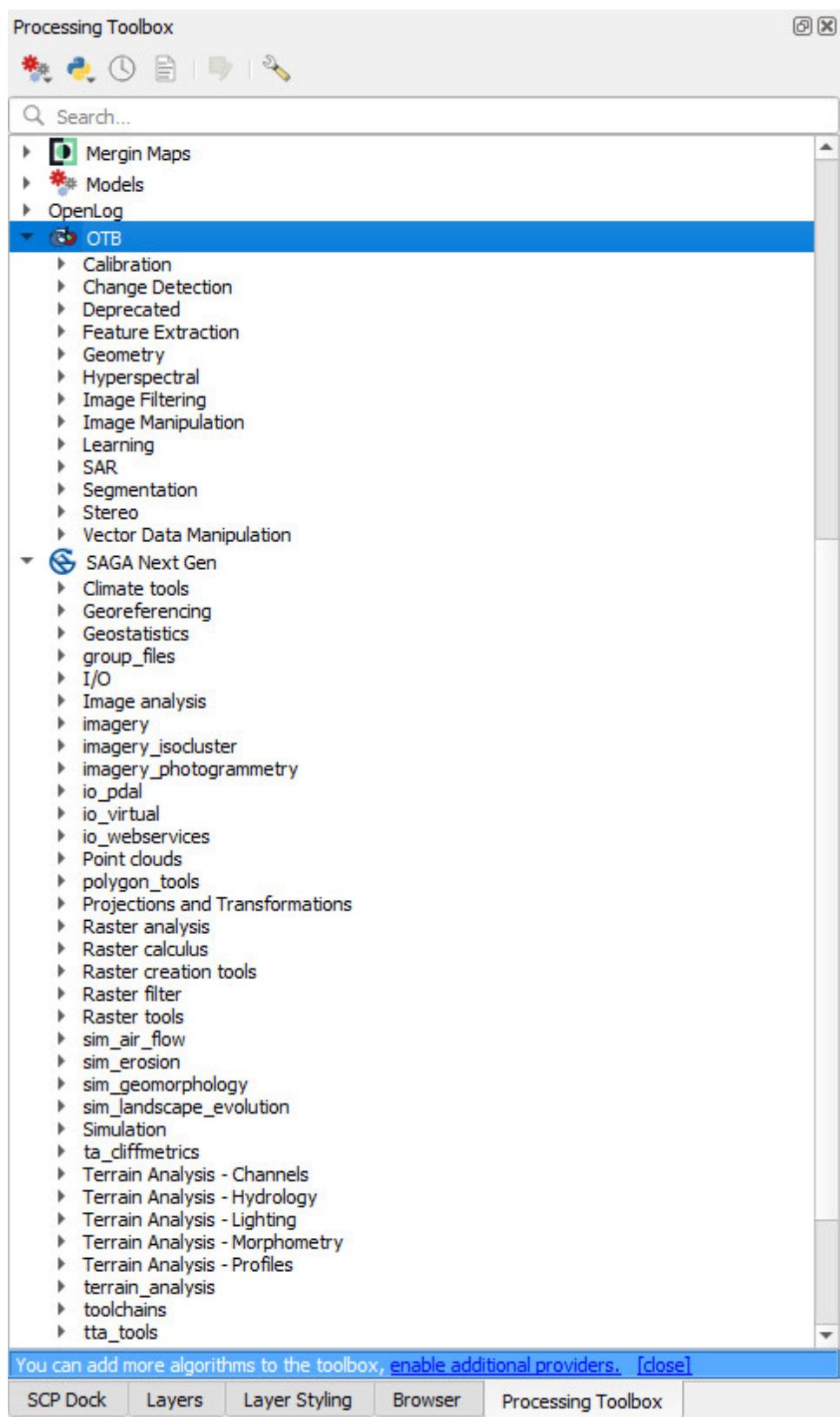
The screenshot shows the official website for Orfeo ToolBox (<https://www.orfeo-toolbox.org>). The header features the Orfeo ToolBox logo and navigation links for Forum, Download, Documentation, Blog, and Community. Below the header is a large banner image showing satellite imagery. A text overlay on the banner reads: 'Orfeo ToolBox is an open-source project for state-of-the-art remote sensing, including a fast image viewer, apps callable from Bash, Python or QGIS, and a powerful C++ API.' Below the banner, the text 'Open Source processing of remote sensing images' is displayed. Two prominent buttons are shown: 'Download OTB 8.1.2' (Released on 2023-07-24) and 'Clone with Git'. A detailed description of the project follows, mentioning its open-source nature, hardware acceleration, and support for various platforms (Linux, macOS, Windows). At the bottom, there's a 'Privacy & Cookies Policy' link.

The screenshot shows the Orfeo ToolBox download page. At the top, there's a navigation bar with links for Forum, Download, Documentation, Blog, and Community. The main heading is "Download". Below it, a note states: "ORFEO ToolBox is distributed as open source under an [OSI-approved license](#). Starting with OTB 6.0, the [Apache 2.0](#) license is used. For prior versions, the [CeCILL v2](#) licence is used. On all platforms, the OTB standalone package contains everything: applications for command line and graphical user interface, python bindings, Monteverdi and also official [remote modules](#)". There are five download buttons: "Windows", "Mac OS", "Linux", "Docker", and "Example image". Below these buttons is a link to "Installation Instructions". A section titled "Notes for Windows install" provides instructions for extracting the archive. It also includes tips for using 7-Zip and information about package management systems for Linux. A note at the bottom says "However be aware that those packages can be older than the latest available and may contain bugs that have already been fixed. Please [click here](#) for details." A "Privacy & Cookies Policy" link is at the bottom right.

Extract the files to a folder on your local machine. This example has put the folder into the C drive root directory in a folder called “OTB-8.1.2-Win64”. Next back in QGIS, open the Processing Toolbox and select the spanner (Settings) icon and enter the location of the OTB folder. You need to click in the right hand side to make the browse buttons appear. The “OTB Applications folder” is located in the OTB xxxx > lib > otb > applications, and the OTB folder points to the upper level OTB folder.



The algorithms then become available in the Processing Toolbox.



# CHAPTER 16

## MORE RESOURCES

### 16.1 On-Line Video Tutorials

There are numerous videos on YouTube that have been created for QGIS and they are all targeted at the general GIS community. However, there are a number of channels that are recommended.

<https://www.youtube.com/@foss4g-sotm-oceania>

<https://www.youtube.com/@geoace>

<https://www.youtube.com/@HansvanderKwast>

<https://www.youtube.com/@qgishome>

<https://www.youtube.com/@WiseGIS>

<https://www.youtube.com/@lunageospatial>

<https://www.youtube.com/@NyallDawson>

<https://www.youtube.com/@automaticknowledge>

<https://www.youtube.com/@KlasKarlsson>

Please contact us to add any additional video links that are of interest to the geosciences.

# CHAPTER 17

## REFERENCES

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# CHAPTER 18

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## LITHOLOGIC PATTERNS FOR GEOLOGICAL MAPS

### 18.1 USGS (FGDC STD-013-2006)

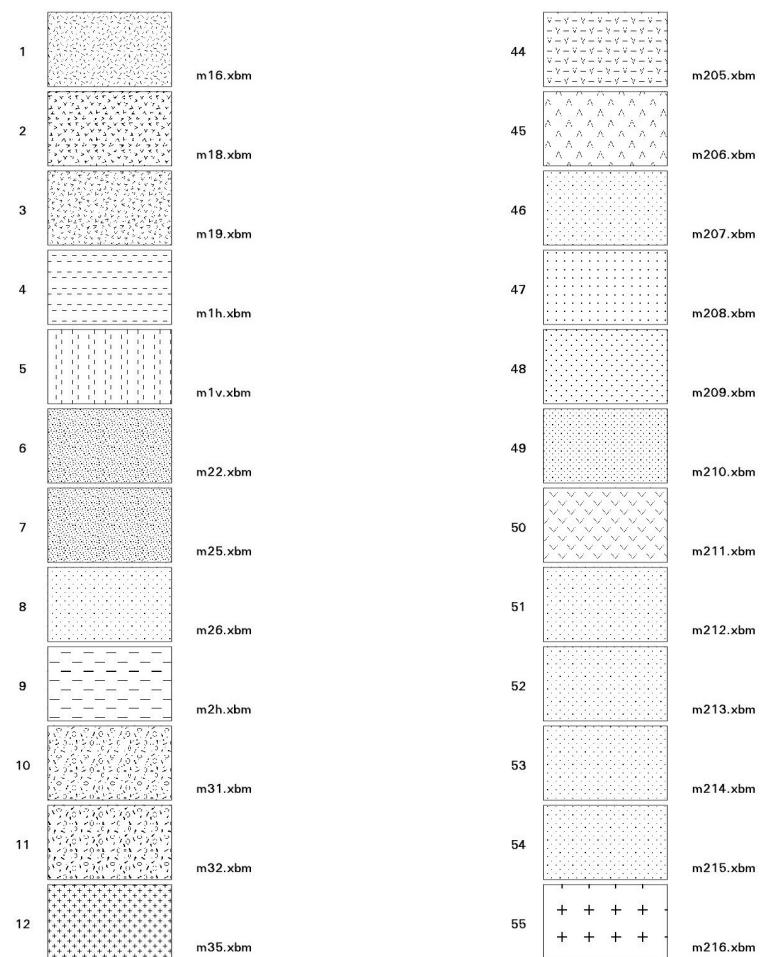
- 37 - Lithologic Patterns (.pdf)
- 38 - Explanation for Pattern Chart (.pdf)

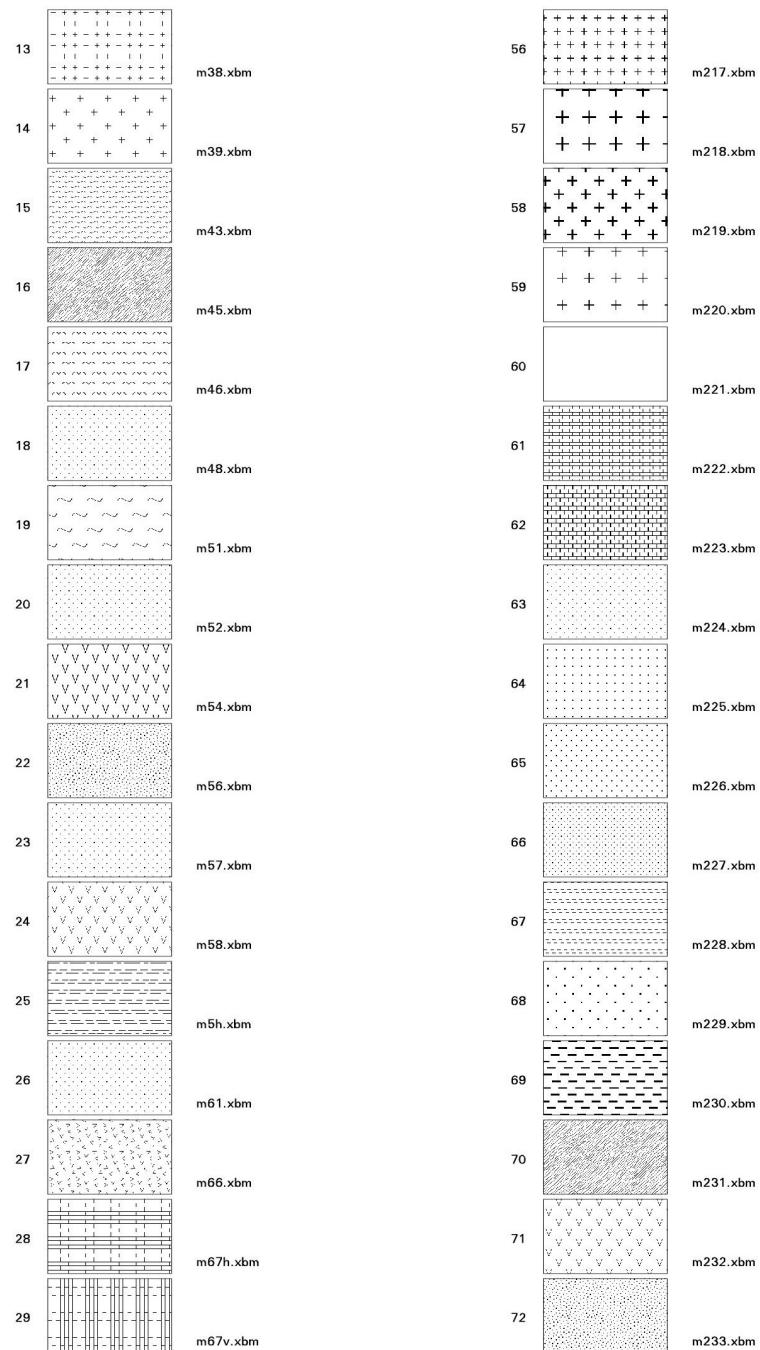
### 18.2 Geoscience Australia

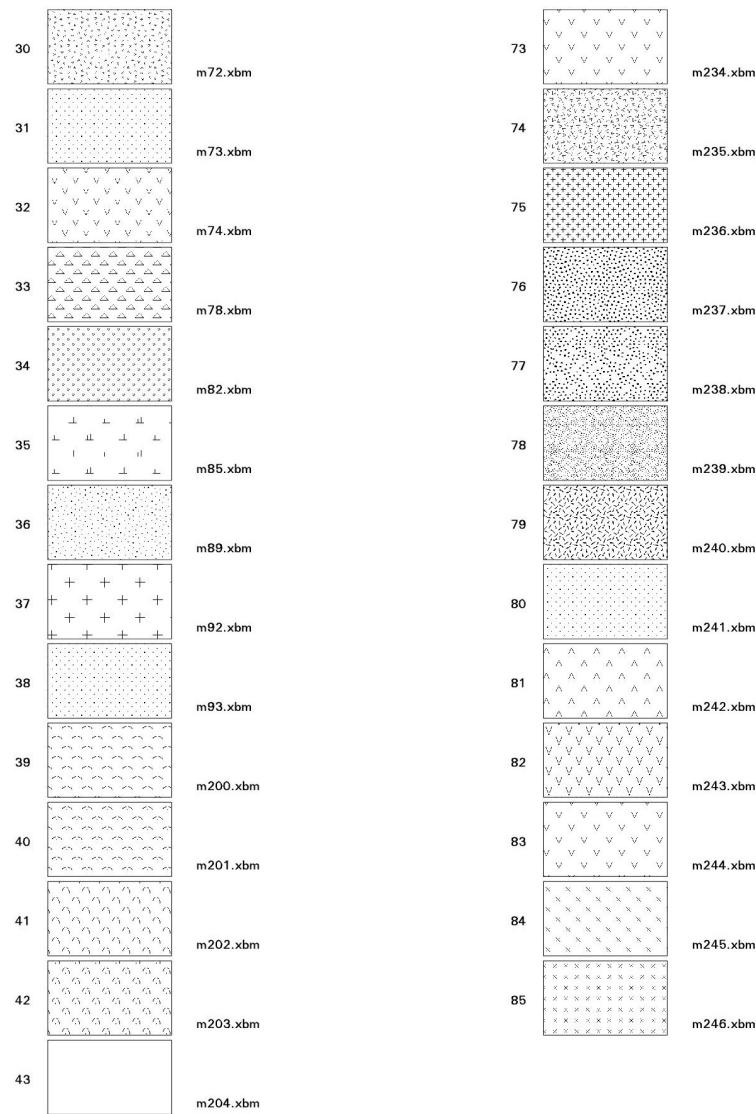
Proposed shadeset: pattern94.shd

## Proposed shadeset : pattern94.shd 19 Jul 95

(some patterns still to be created)







## 18.3 Geological Survey of Western Australia

GSWA style guides

Guide to editing maps

Guide to editing maps, pg.94



March 2018