



Working Draft

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Using QGIS v3 in Mineral Exploration



Version 3.6

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1: SUMMARY

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. There is no dedicated drill hole or cross section module available for QGIS currently, but discussions and plans are progressing to develop this module in the future. The Geoscience plugin is a basic drill hole display option.

This manual examines QGIS and how QGIS can assist geoscientists to undertake mapping and geoscientific tasks in their day-to-day work. The manual has evolved during several years teaching QGIS to geoscientists in Western 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.

QGIS has many plug-ins for specialised tasks and the semi-automatic classification plug-in (SCP), is one example 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 version 3.6. Please feel free to share this document.

2: INTRODUCTION

This document is aimed at the exploration geologist in Western Australia, 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 3.6.

The reader is encouraged to join the international online QGIS user forum at <http://lists.osgeo.org/mailman/listinfo/qgis-user> and the Western Australian QGIS user group (contact the author for details).

This document will not go into the detail that is covered by the QGIS User Guide and Training Manuals (<https://docs.qgis.org/testing/pdf/en/>) 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 - <https://youtu.be/jZYKGrlyVCA>.



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 however, an old format and has limitations, e.g. field names are limited to 10 characters. QGIS is adopting the new “Geopackage” file format as its default spatial file format. Geopackage files can have 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 in the Browser panel. Styling information can 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 without any major loss of quality. ESRI products can read Geopackage files.

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

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.

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 work place, 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. You can visualize, manage, edit, analyse data, and compose printable maps.

This document will mainly deal with work flows 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 keen to crowd source the development of the drill hole plug-in. The 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 complete revision of QGIS has been undertaken with the release of version 3. Although the user interface is similar there has been an extensive re-write of the software behind the interface.

A good explanation of QGIS and where it came from can be found here <https://www.youtube.com/watch?v=As4hfPecxoU>.

If you find QGIS makes a valuable contribution to your business, please consider making a donation to assist with continual code improvements – see this link <https://qgis.org/en/site/getinvolved/donations.html>.



Installation options are available on QGIS download page (<https://qgis.org/en/site/forusers/download.html>) with options to download either the development version (via OS4Geo), the v3 standalone installer (recommended) or the v2 standalone installer (no longer being updated). Both 64 and 32 bit versions are available.

QGIS has been using ESRI shapefiles as the default spatial file format but the new “GeoPackage” format is far superior and will probably become the default file format for QGIS in the near future.

Shape files 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 <https://carto.com/blog/fgdb-gpkg/>.

4: INSTALLING QGIS

4.1 PC Installation

The QGIS program can be downloaded from the QGIS Project website <http://www.qgis.org/en/site/> and a choice can be made between 32 and 64 bit versions of the recent release and long term release version (3.4). Note that the v2 options are no longer supported and users are encouraged to use v 3. The Standalone Installers will install the program into the Program Files directory.

The OWGeo4W option can also be used and 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 users, it is recommended to install the “Standalone” version.



Download for Windows

QGIS in OSGeo4W:

OSGeo4W Network Installer (64 bit)

OSGeo4W Network Installer (32 bit)

In the installer choose **Desktop Express Install** and select **QGIS** to install the *latest release*.
 To get the *long term release* (that is not also the latest release) choose **Advanced Install** and select **qgis-ltr-full**
 To get the *bleeding-edge development build* choose **Advanced Install** and select **qgis-dev-full**

Standalone installers from OSGeo4W packages

Latest release (richest on features):

QGIS Standalone Installer Version 3.6 (64 bit)

md5

QGIS Standalone Installer Version 3.6 (32 bit)

md5

Long term release repository (most stable):

QGIS Standalone Installer Version 3.4 (64 bit)

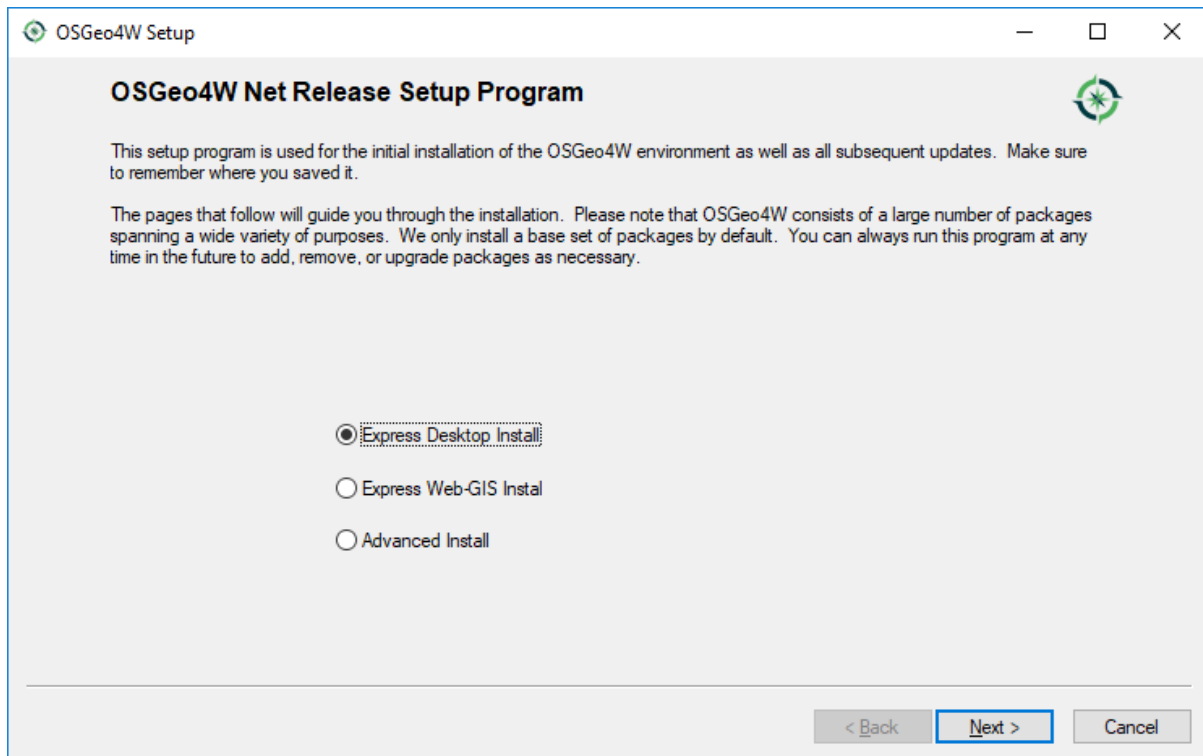
md5

QGIS Standalone Installer Version 3.4 (32 bit)

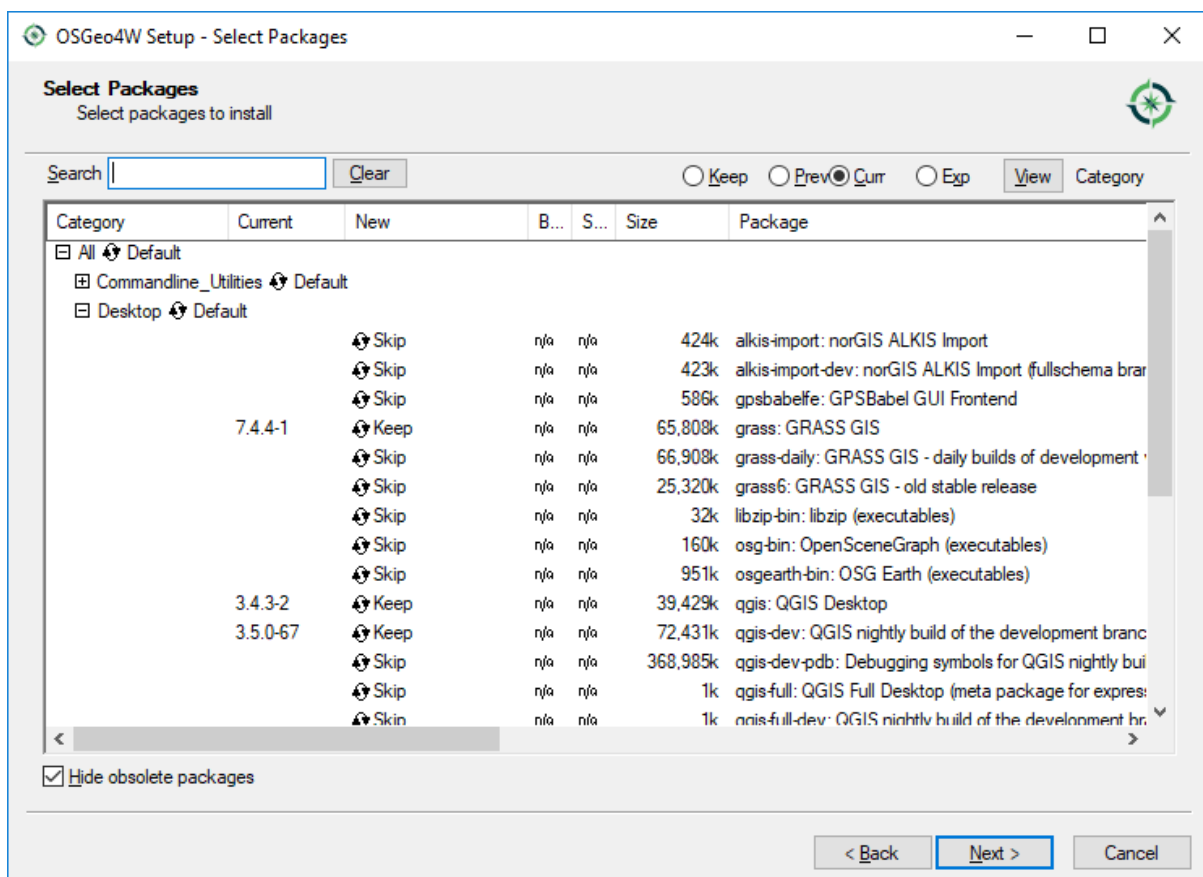
md5

The standalone installer 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 x.x with GRASS 7.x.x” version which runs the GIS program and associated GRASS GIS functions.

When you run the OSGeo4W option you see the following screen shot. For a first-time installation, choose the “Express Desktop Install” which will install the programs and required utility files.

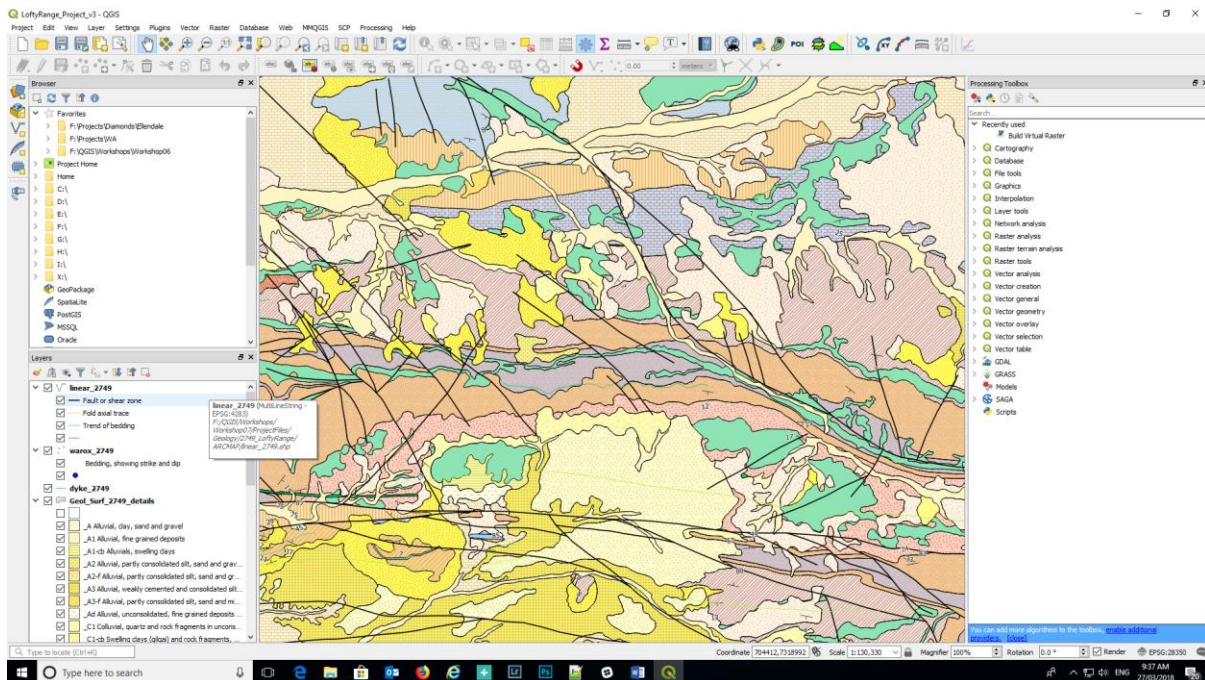


After the initial “Desktop Install”, you can then check for updates by running the “osgeo4w-setup-x86_64.exe” file again (usually located in the Downloads folder) where you can select “Advanced Install” and select which products you wish to update. The OSGeo4W option can be used instead of the Standalone Installer option.





User manual and training documents can be viewed, or pdf versions downloaded from the QGIS web site (<https://qgis.org/en/docs/index.html>).



The 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 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 at this time to use the link at Lutra Consulting (<https://lutraconsulting.github.io/qgis-mac-packager/>) to download and install QGIS.

Install the LTR or the Latest Release version.



Download QGIS

Package contains standalone QGIS installation, with bundled Python3, Qt, GDAL, GRASS, SAGA and other dependencies.

Please report any issues on [GitHub issue tracker](#)

- [Long Term Release 3.4.5](#)
- [Latest Release 3.6.0](#)
- [Nightly Builds \(master\)](#)

Notes

- Minimum supported MacOS version is 10.13 ([details](#))
- QGIS **must be installed** in /Applications/QGIS<version>.app

Highlights

- Supports Dark Mode (Mojave 10.14+)
- Single installer, all dependencies bundled in the package
- Signed installer and application
- Nightly builds
- Allows installation of different versions side-by-side
- Transparent server setup, all scripts/docs can be found [here](#)
- Embeds his own version of Python 3 in the package
- Embeds all Proj's datumgrids

Build Details

MacOS version is 10.14

Package was built with XCode 10.1 (10B61)

Used Homebrew's packages

- ant 1.10.5
- aom 1.0.0
- apr 1.6.5
- apr-util 1.6.1_1
- armadillo 9.300.2
- arpack 3.7.0
- atk 2.32.0
- bison 3.3.2
- boost 1.69.0

This project is maintained by [lutraconsulting](#)

[View the Project on GitHub](#)
lutraconsulting/qgis-mac-packager

Hosted on GitHub Pages — Theme by [orderedlist](#)

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.



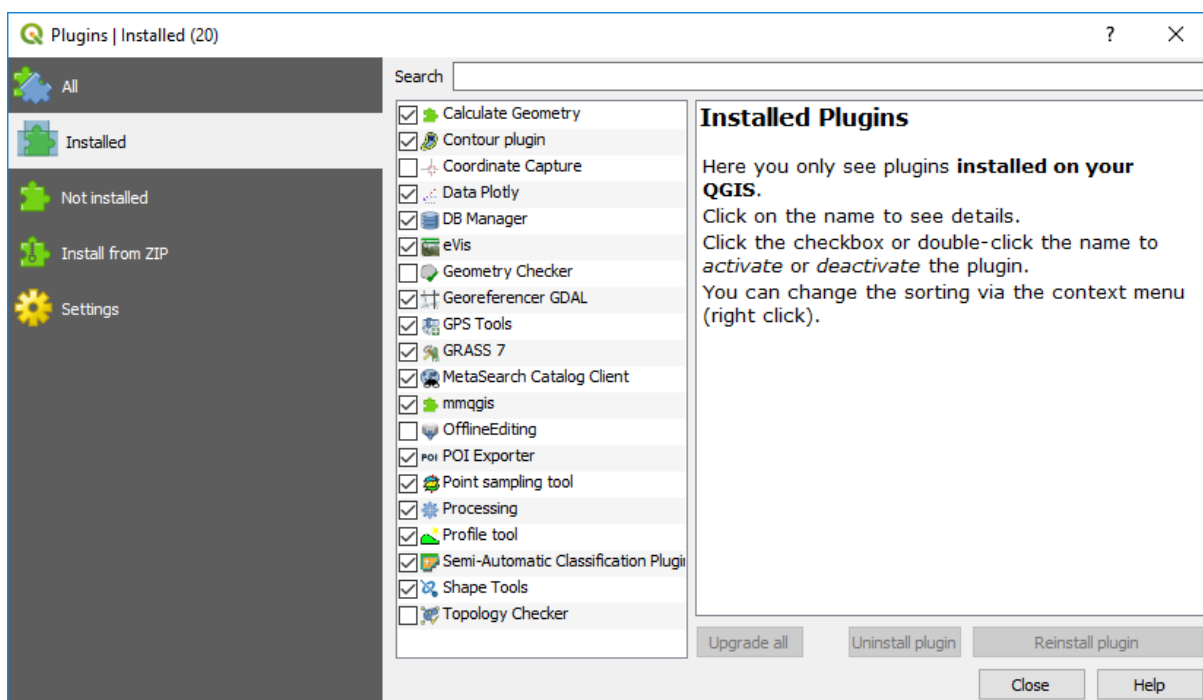
5: PLUG-INS

Plug-ins are small utility programs that greatly expand the capabilities of QGIS. There are currently over 450 plug-ins available for download. These plug-ins 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.

Eleven plug-ins are installed by default in version 3.6 as are listed below.

Coordinate Capture
DB Manager
eVis
Geometry Checker
Georeferencer GDAL
GPS Tools
GRASS7
MetaSearch Catalog Client
Offline Editing
Processing
Topology Checker

To use these pre-installed plug-ins, you may need to enable them in the Plug-Ins > Manage and Install Plug-Ins > Installed window. Enable the plug-ins by selecting the check box next to the plug-in.



Additional plug-ins that are recommended are as follows;

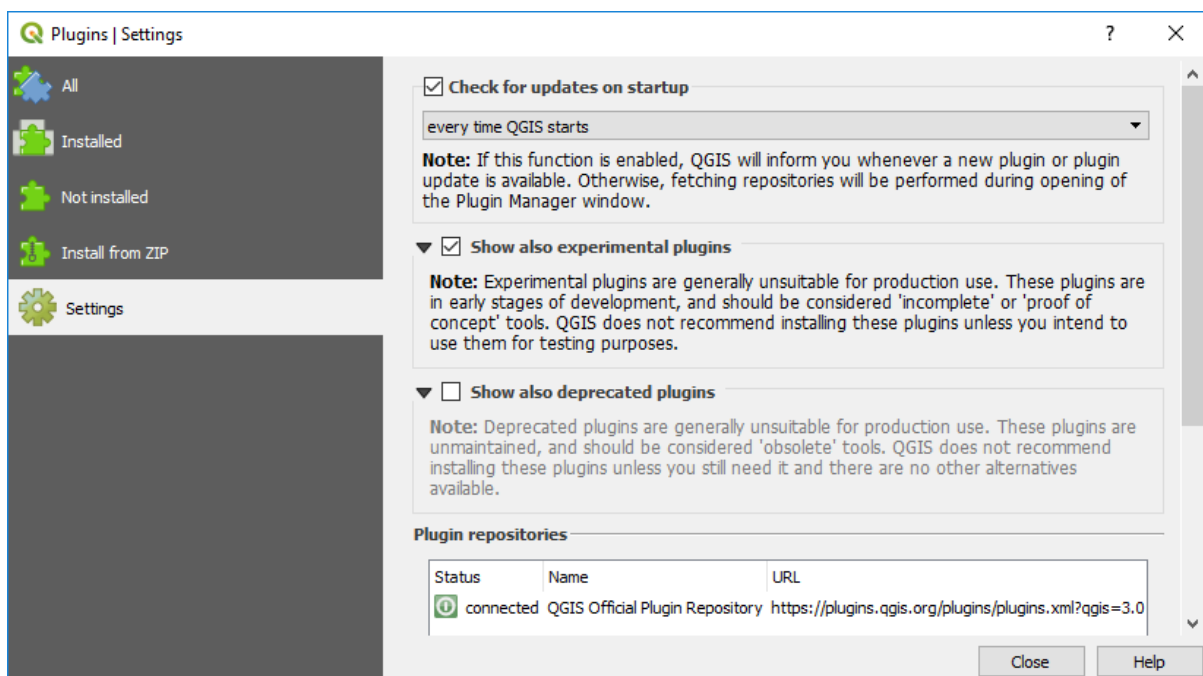
Calculate Geometry
Data Plotly (graphing of data)
Geoscience (experimental, for plotting drill holes on plans and sections)
importPhotos (import photos with embedded GPS coordinates)
MMQGIS (various selection and geocoding tools)
POI Exporter (useful for uploading points to a GPS unit)
QuickMapServices (add additional services under the extra services option)
QFieldSync (synching project for use in QField and creating basemaps)



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)
 Virtual Raster Builder (alternative method to create RGB images)

If the QGIS start-up is being significantly delayed during start-up (“Loading Plugins”) then they can be temporarily disabled (Plugins > Installed, tick off those not needed) and only turned on when needed.

In the Plug-Ins > 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 plug-ins and the release of new plug-ins 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 Plug-in’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.



6: DATA MINING AND PUBLIC DATASETS

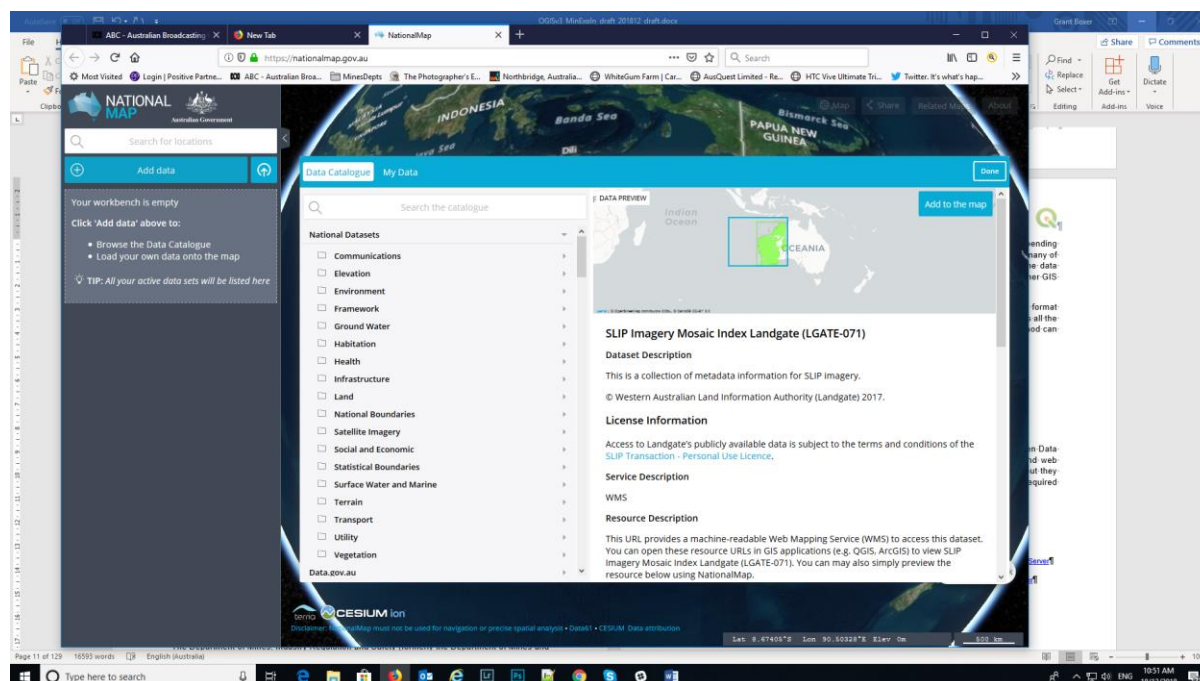
Many government and private corporations have made available datasets for use in GIS programs. There may be usage restrictions and the conditions of use should be checked at the data source. The amount of free data on the web is truly amazing and users are encouraged to explore the web for data.

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 (<https://nationalmap.gov.au>) where data can be accessed for Australia-wide data sets or from the individual states and territories. The WA DMIRS (WA mines dept) data can also be accessed via this portal.





6.2 Geological Survey of Western Australia

The Department of Mines, Industry Regulation and Safety (formerly the Department of Mines and Petroleum, <http://www.dmp.wa.gov.au/>) is home to the Geological Survey of Western Australia (GSWA). This site contains many data sets, most of which can be downloaded from the “Software and Data Centre” (<https://dasc.dmp.wa.gov.au/dasc/>). Raster and vector data can also be accessed live via their WMS and WFS services (http://geodownloads.dmp.wa.gov.au/downloads/dasc/Static/Resources/Map_Services/Image_Web_Service_definition.pdf and http://geodownloads.dmp.wa.gov.au/downloads/dasc/Static/Resources/Map_Services/Web_Map_Service_definition.pdf).

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.

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. This is a work in progress. North Road Consulting are developing a plugin to convert “lyr” style files to QGIS style files and this will go a long way in allowing QGIS users to style their maps in a similar fashion to the Arc GSWA maps.

6.3 Landgate and Open Data WA

The WA government has made available a large variety of GIS datasets through their Open Data website (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;

WMS Links

Public:

https://services.slip.wa.gov.au/public/services/SLIP_Public_Services/Property_and_Planning/MapServer/WMSServer

Imagery: https://services.slip.wa.gov.au/public/services/SLIP_Public_Services/Locate/MapServer/WMSServer

WFS Links

Maps

https://services.slip.wa.gov.au/public/services/SLIP_Public_Services/Property_and_Planning_WFS/MapServer/WFSServer

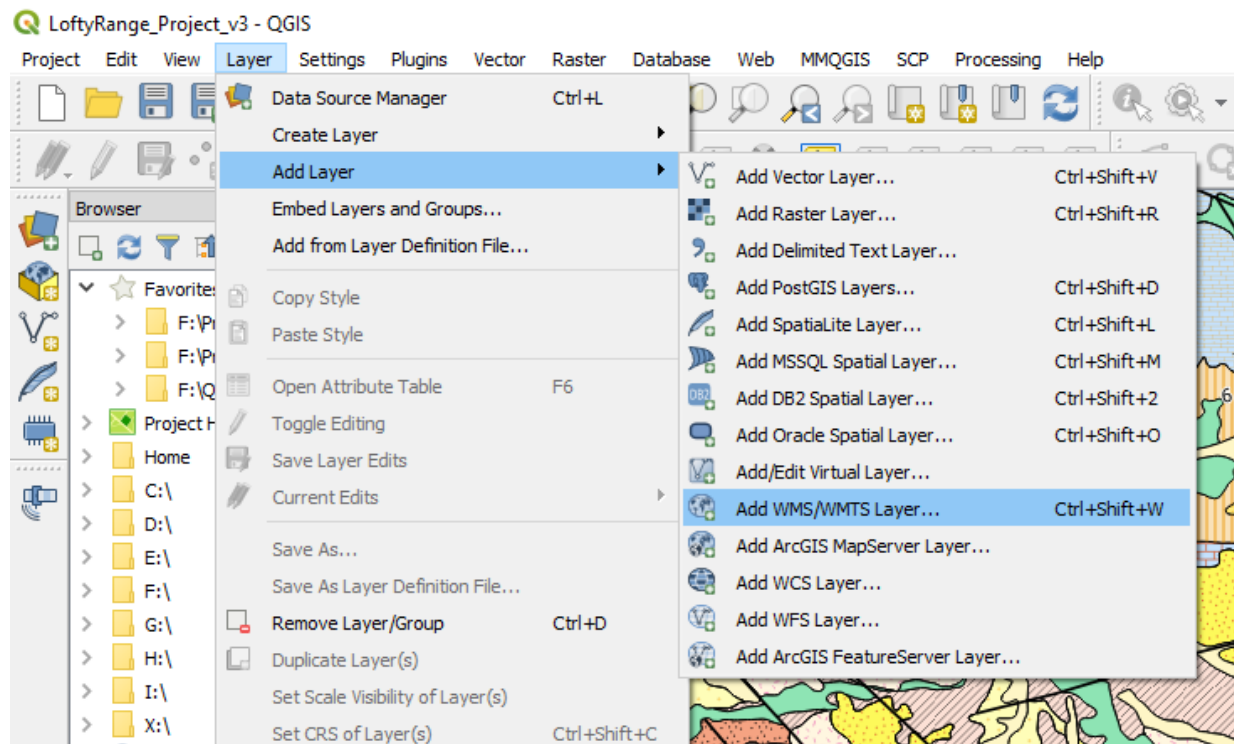
Imagery

https://services.slip.wa.gov.au/public/services/SLIP_Public_Services/Imagery_and_Maps_WFS/MapServer/WFSServer

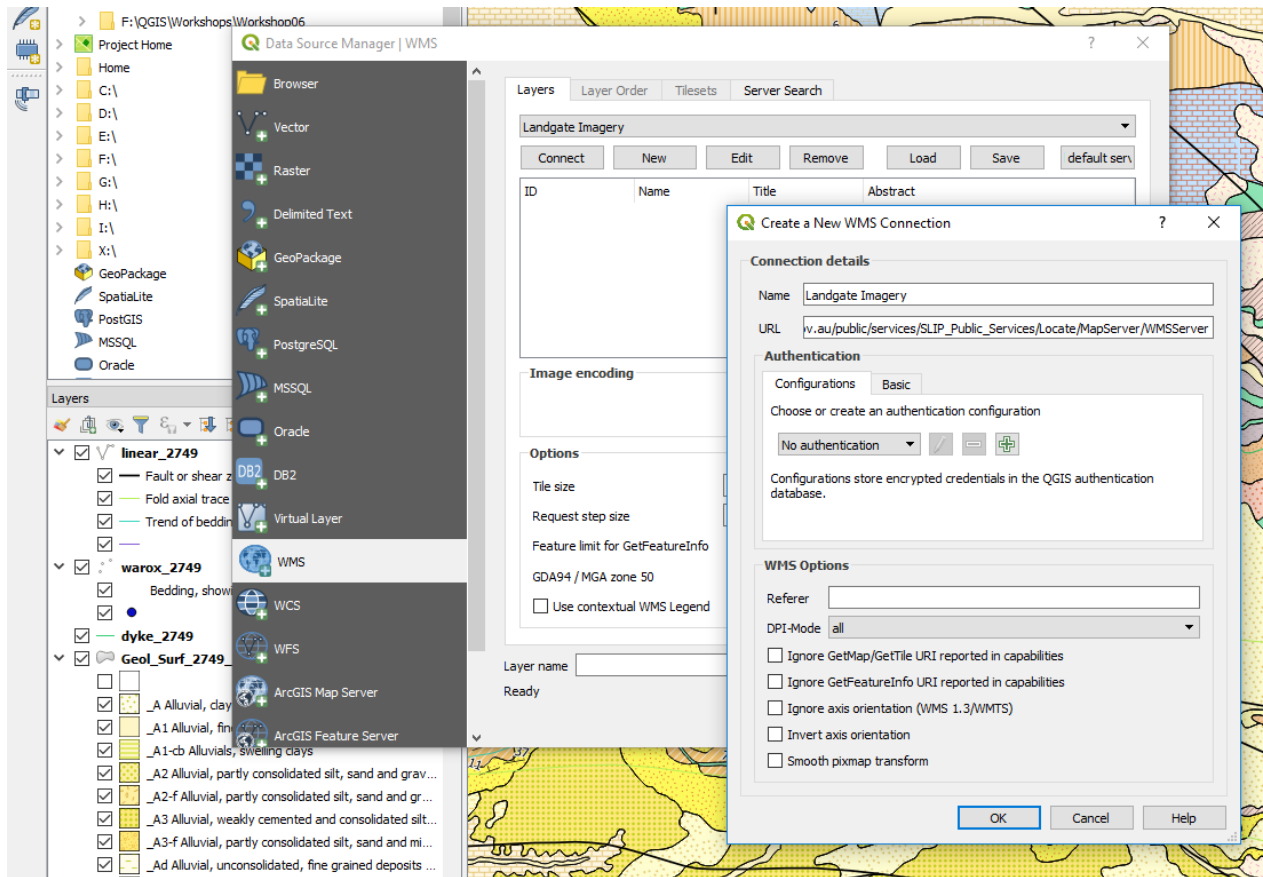


Australian Bureau of Statistics: https://www2.landgate.wa.gov.au/ows/wfsabs_4283/wfs

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

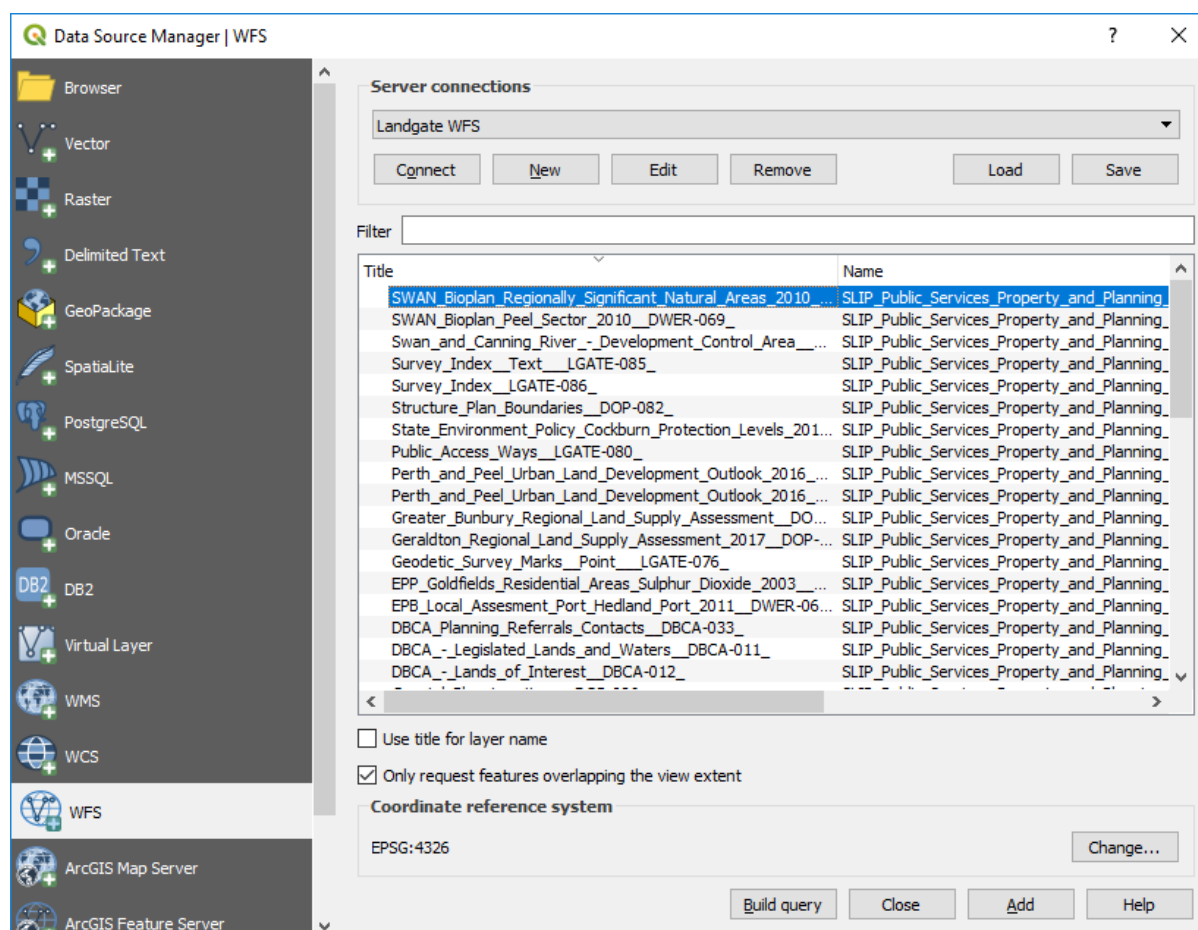


An example of linking to the Landgate imagery is shown below.



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

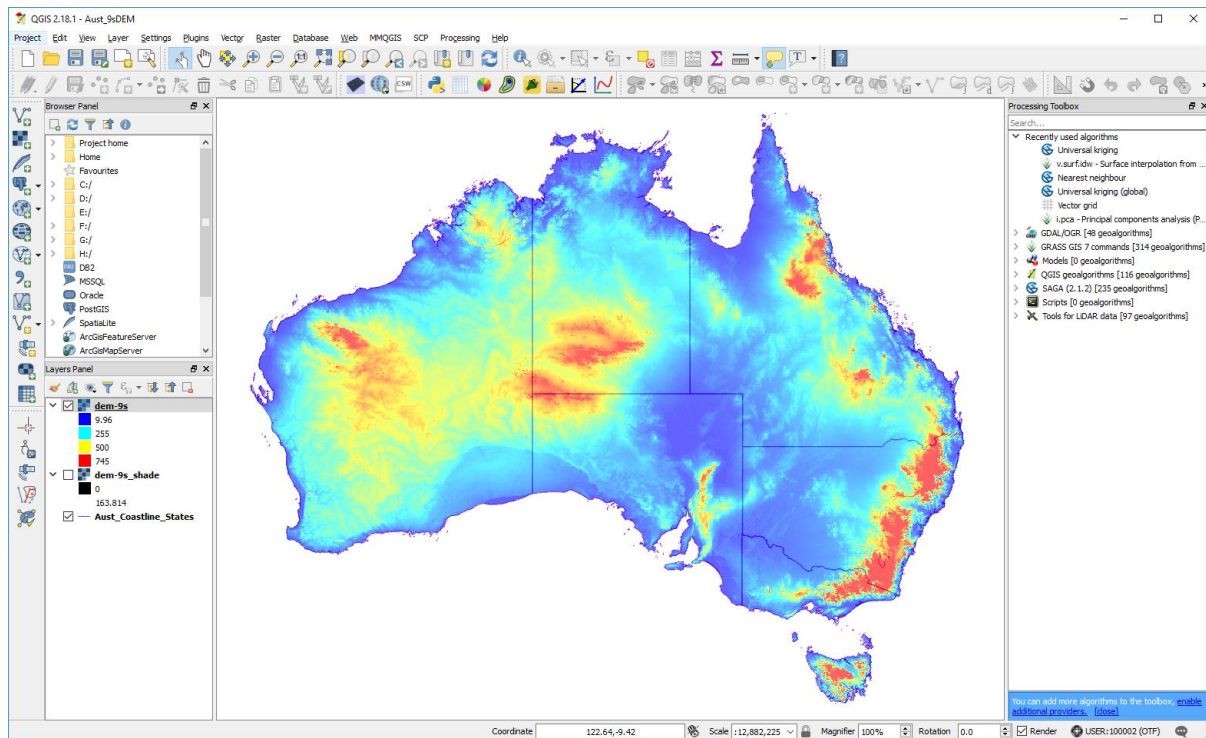
Access to vector data is via the add WFS (web feature server) option. See below for the list of publicly available data (no sign in required) from the Landgate server.



6.4 Geoscience Australia

Geoscience Australia (GA) provides an extensive array of national datasets (see this link for more information "data.gov.au/dataset").

Digital elevation data is also available across Australia from Geoscience Australia (<http://www.ga.gov.au/elvis/>) 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 and the author has cut this into UTM zones which are approximately 7 - 8 Gb in size each zone to improve useability. 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.



Geoscience Australia, 9 second DEM

Many of these datasets are also available as web services – see this link <http://services.ga.gov.au/>.

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 (GADDs). The DMIRS 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.



Geoscience.gov.au

Geophysical Archive Data Delivery System

This system provides magnetic, radiometric, gravity and digital elevation data from Australian National, State and Territory Government geophysical data archives.

Define your area of interest

Lat/Long Rectangle

N Lat.

W Long. E Long.

S Lat.

[use decimal degrees (e.g. 137.821)]

Quick Start

1:250k Map Sheet:

Choose Map Name/Number

Additional Layers:

- ☐ Digital elevation model
- ☐ Magnetics
- ☐ Gravity
- ☐ Geological Regions
- ☐ Population centres
- ☐ Roads
- ☐ Railways
- ☐ 1:250 000 map sheets
- ☐ 1:100 000 map sheets

Basic Instructions

Option 1:

Enter the extents in the Lat/Long Rectangle form as decimal degrees (e.g. 137.821) then click the "proceed to download" button beside it.

Note:

W Long = Western Boundary Longitude
E Long = Eastern Boundary Longitude
S Lat = Southern Boundary Latitude
N Lat = Northern Boundary Latitude

Option 2:

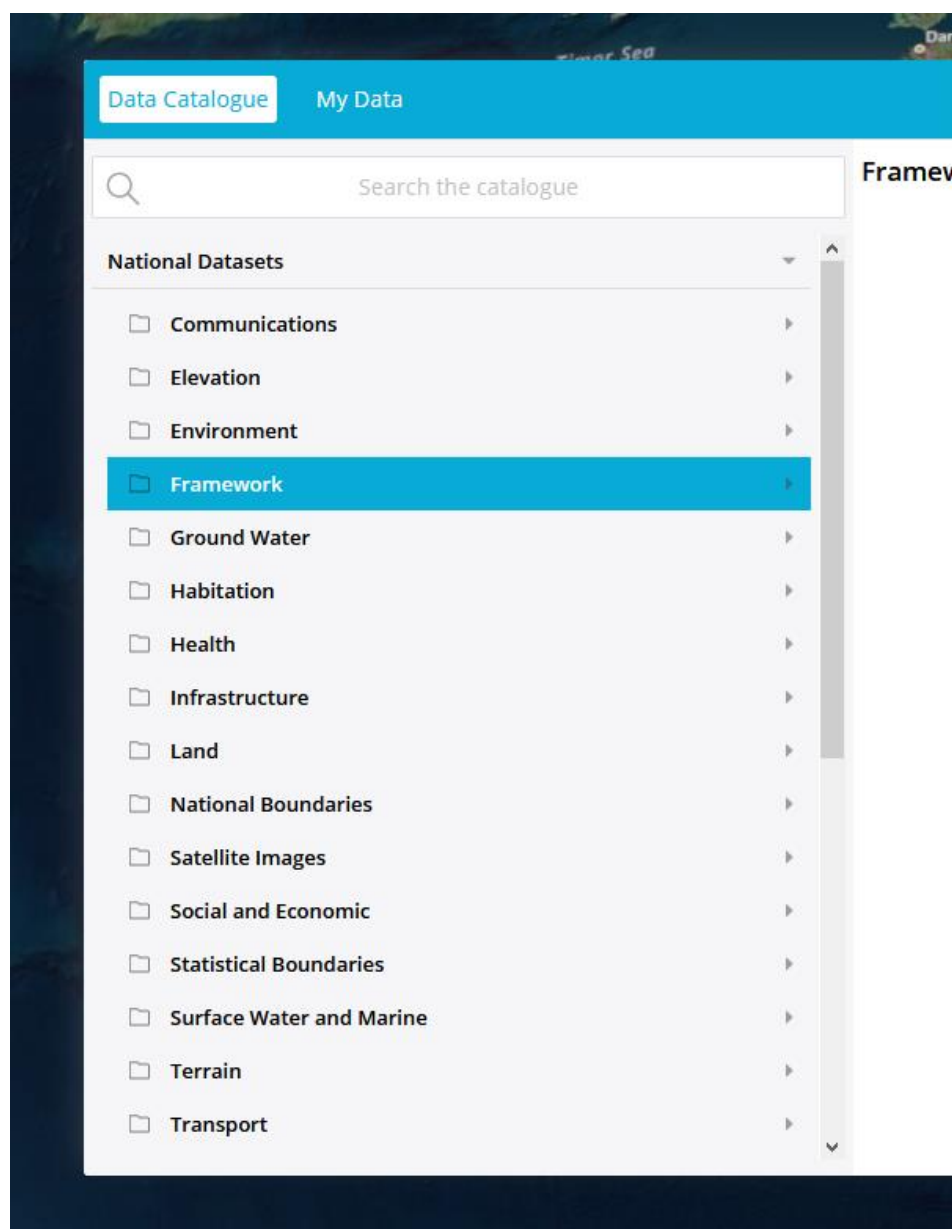
Use the map query tool () to define your area of interest. The Lat/Long rectangle form will be automatically populated with the extents of the area you define, then click the "proceed to download" button beside the form.

Option 3:

Use the "Quick Start" menu to choose an area of interest based on a 250k map sheet. Choosing a map sheet will populate the Lat/Long Rectangle form, then click on the

Geoscience Australia geophysical data portal.

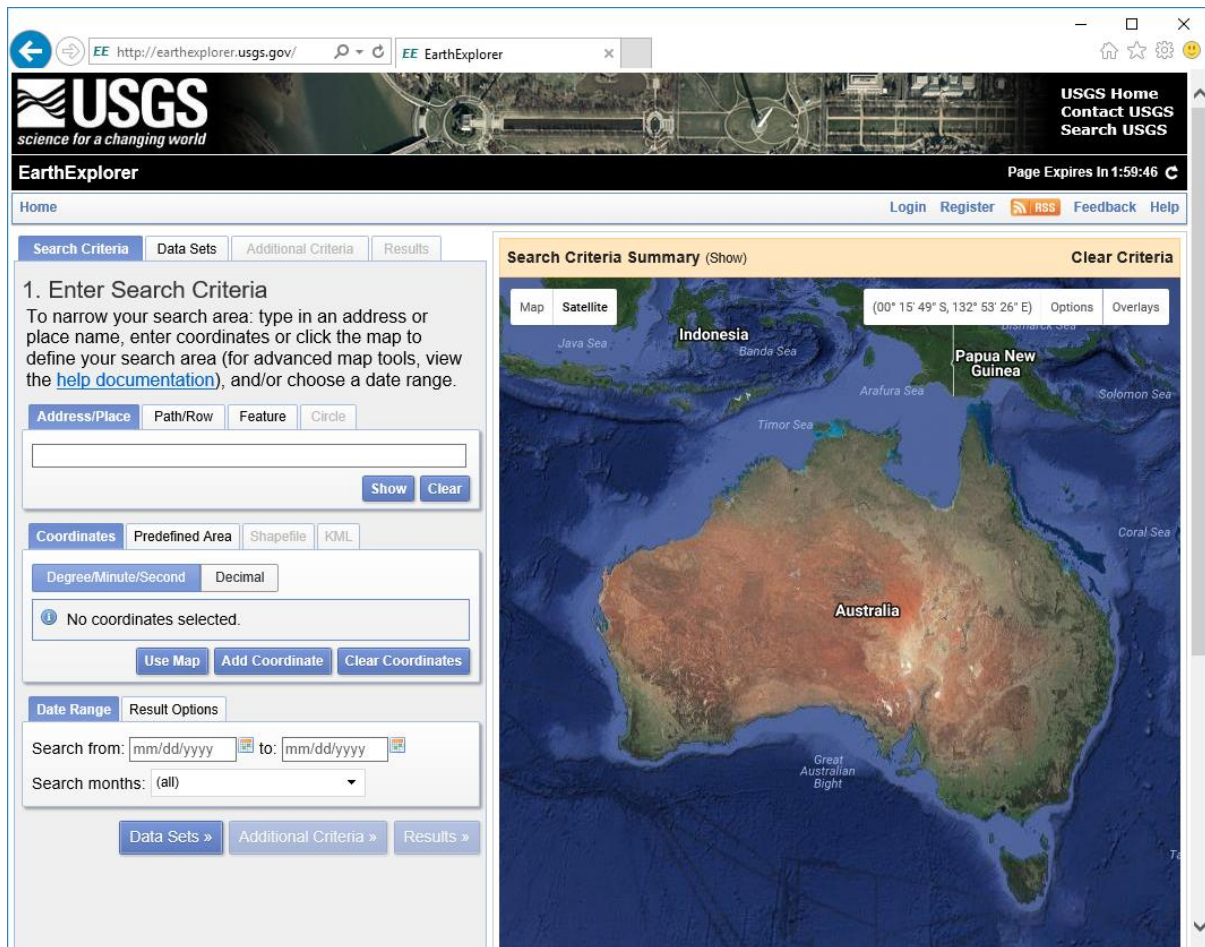
GA have recently released a new Digital Earth Australia data portal at "eos.ga.gov.au". It currently holds "Water Observations from Space Data" but additional datasets are being developed to assist in land management (see <http://eos.ga.gov.au/geoserver/NFRIP-WOfS/wms?>).



6.5 United States Geological Survey (USGS)

The USGS hold an enormous amount of free data, most of which is accessible via its EarthExplorer portal (<http://earthexplorer.usgs.gov/>). 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 more 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.



USGS EarthExplorer data 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.



Search CriteriaData SetsAdditional CriteriaResults

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:

+

Aerial Imagery

+

AVHRR

+

CEOS Legacy

+

Commercial Satellites

+

Declassified Data

+

Digital Elevation

+

Digital Line Graphs

+

Digital Maps

+

EO-1

+

Global Fiducials

+

Global Land Survey

+

HCMM

+

ISERV

+

Land Cover

+

Landsat Archive

+

Landsat Legacy

+

Landsat MRLC

+

NASA LPDAAC Collections

+

Radar

+

Sentinel

+

Vegetation Monitoring

Clear All Selected

Additional Criteria »

Results »

Each of the data categories have a range of datasets available.

science for a changing world

EarthExplorer

Home New System Messages Save Criteria Load Favorite Manage Criteria

Search CriteriaData SetsAdditional CriteriaResults

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 »](#)

Sentinel-2

1

Entity

ID:S2A_OPER_MSI_L1C_TL_SGS__20160810T022734

Coordinates:-29.4220525 , 117.5657589

Acquisition Date:2016/08/10

2

Entity

ID:S2A_OPER_MSI_L1C_TL_SGS__20160320T021746

Coordinates:-29.4220525 , 117.5657589

Acquisition Date:2016/03/20

3

Entity

ID:S2A_OPER_MSI_L1C_TL_SGS__20160219T021747

Coordinates:-29.4220525 , 117.5657589

Acquisition Date:2016/02/19

4

Entity

ID:S2A_OPER_MSI_L1C_TL_MTI__20151221T021751

Coordinates:-29.4220525 , 117.5657589

Acquisition Date:2015/12/21

« First » Previous

Next » Last »

View Item Basket »

Submit Standing Request »

Search Criteria Summary (Show)

Map Satellite

The up-to-date Google map is not for purchase or for download; it is to be used as a guide for reference and search purposes only

Page | 19



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.

6.6 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 <https://sentinel.esa.int/web/sentinel/home>). For geological work, the author has found the Sentinel 2 that most useful. The Sentinel 2 mission monitors variability in land surface conditions, and its wide swath width and high revisit time (10 days at the equator with one satellite (2A), and 5 days with 2 satellites (2A and 2B) under cloud-free conditions which results in 2-3 days at mid-latitudes) will support monitoring of changes to vegetation within the growing season. The coverage limits are from between latitudes 56° south and 84° north (ESA). The second Sentinel 2 satellite (2B) has recently (2017) been launched and commissioned.

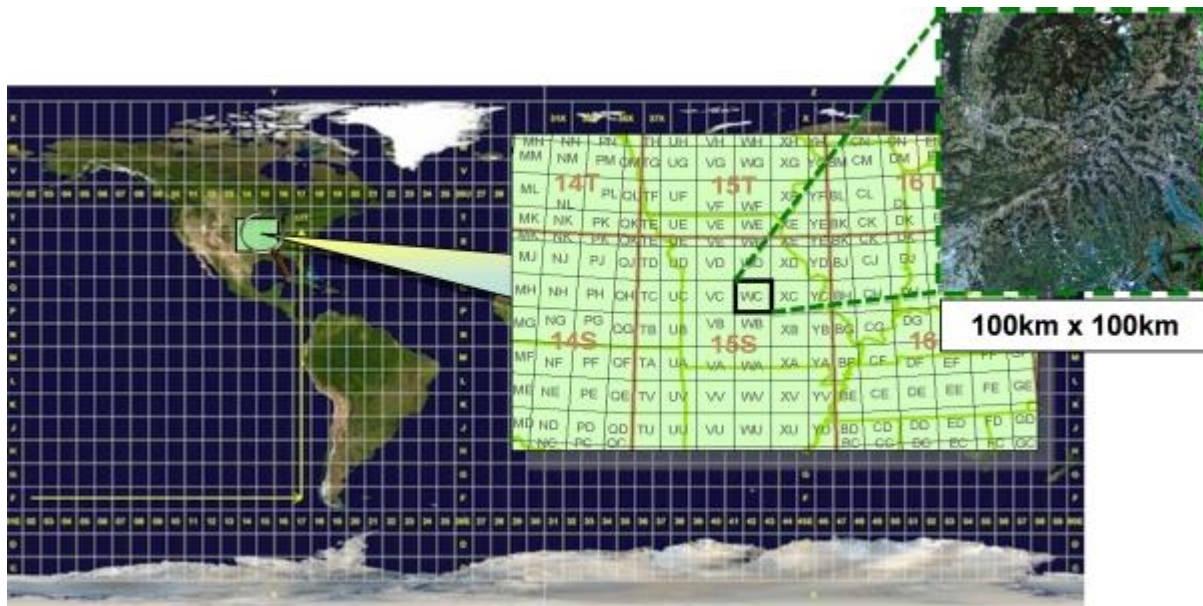
The following description is taken from the ESA Sentinel website.

“Sentinel-2 products available for usersare 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 km ²)
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 km ²)

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.



Level-1C product tiling

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)."

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.



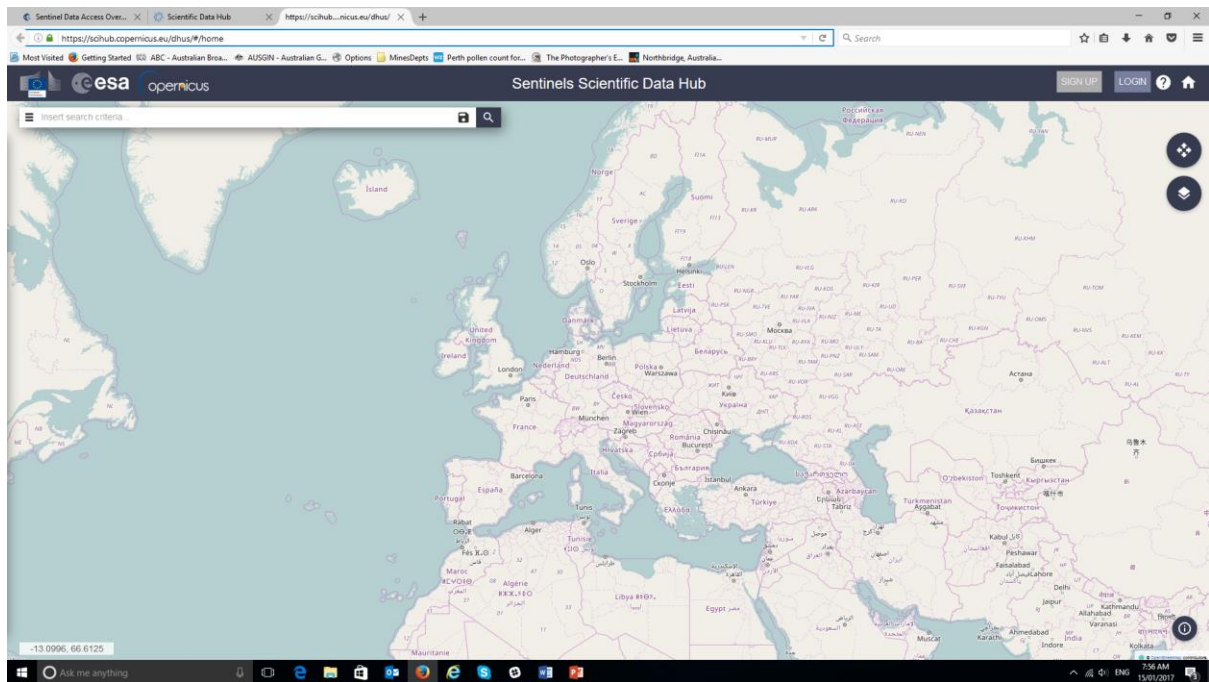
Spectral bands for the SENTINEL-2 sensor

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 (µm)	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 be accessed via the Sentinel portal after registration (Sign Up button), see this link <https://scihub.copernicus.eu/dhus/#/home>.



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

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

Sentinel 2 data is more easily 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.

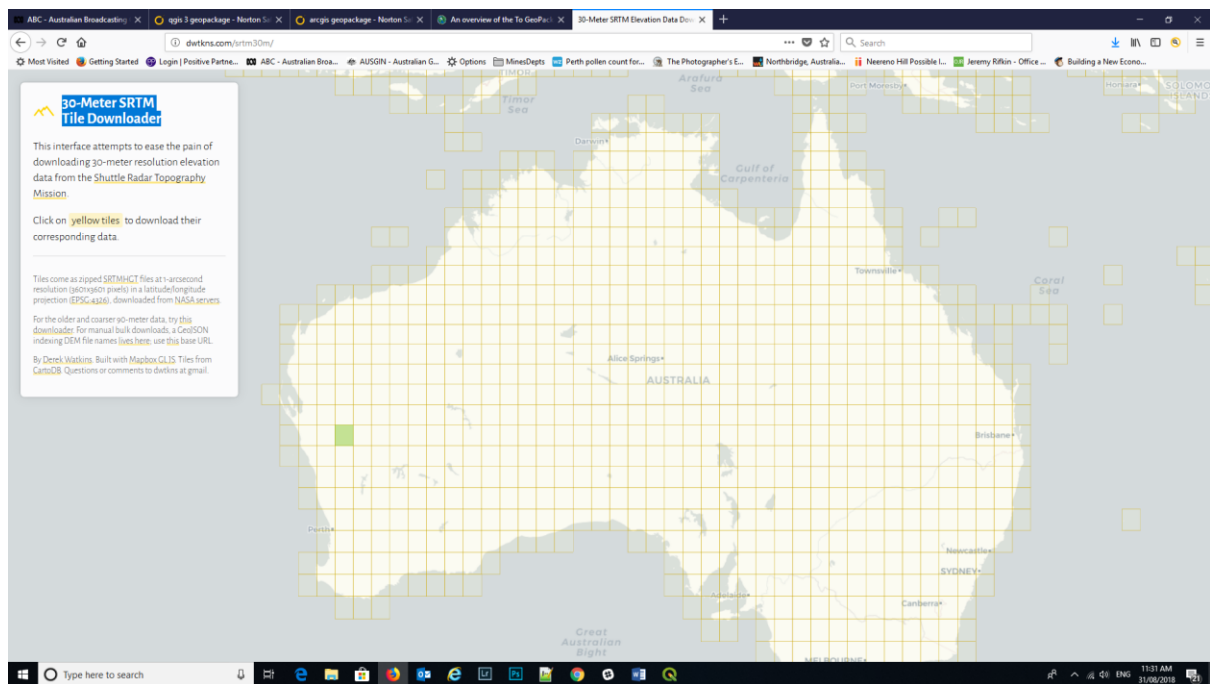
6.7 30 m SRTM Tile Downloader

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 images 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 - <http://dwtkns.com/srtm30m/>. You will need to add your USGS EarthExplorer user name and password.



QGIS v3 In Mineral Exploration



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



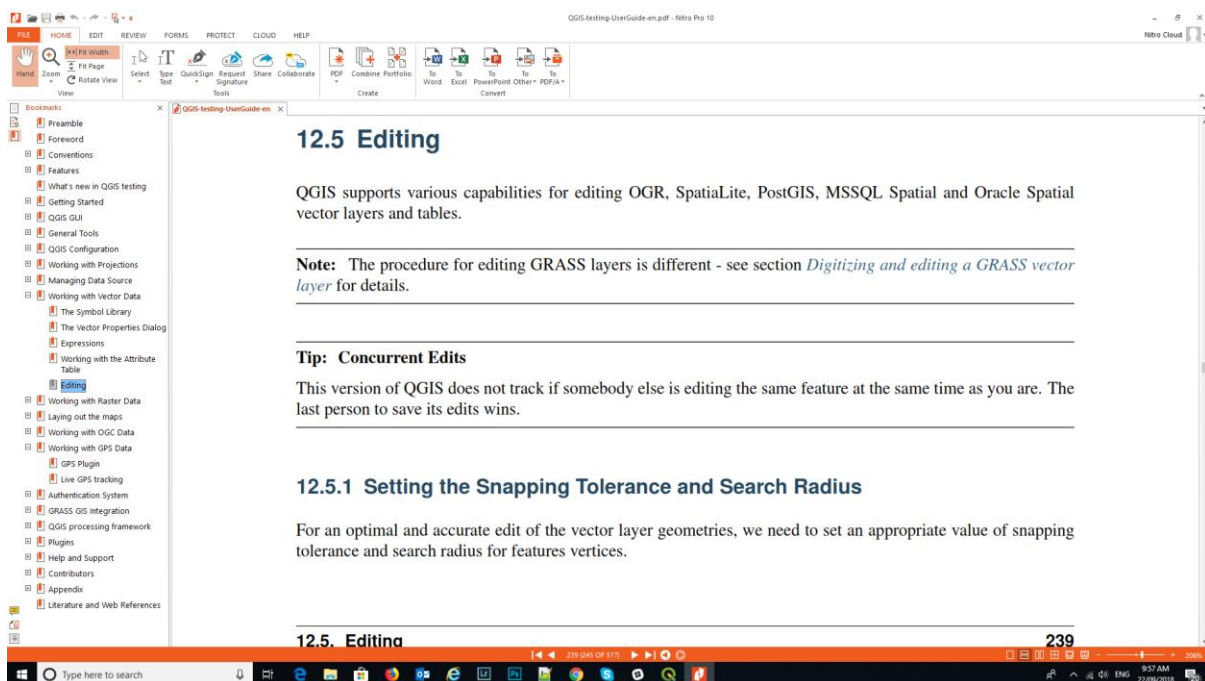
7: GEOLOGICAL DATA

Geological data is varied in nature but is usually 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. 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 a number of resources available on the web and 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” is available and more details on this will be added in the near future. QField can 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 a later date into a different projection if required.

Note also 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 – Release Testing” (for version 3.6) document which can be found here <https://docs.qgis.org/testing/pdf/en/>. This guide gets regularly updated.



7.1 Point Data

Field mapping data is collected by a number of methods. The most basic version and that used by the “old school” is to collect data in our 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.

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



imported via the “GPS Tools” icon located in the left menu bar or via the top menu Vector > GPS > GPS Tools menu. GPX files from Garmin GPS units are usually in WGS84 geographic coordinates (Longitude and Latitude, decimal degree format) by default.

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 export file, save the file in CSV format and import into QGIS.

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 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 are 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)”

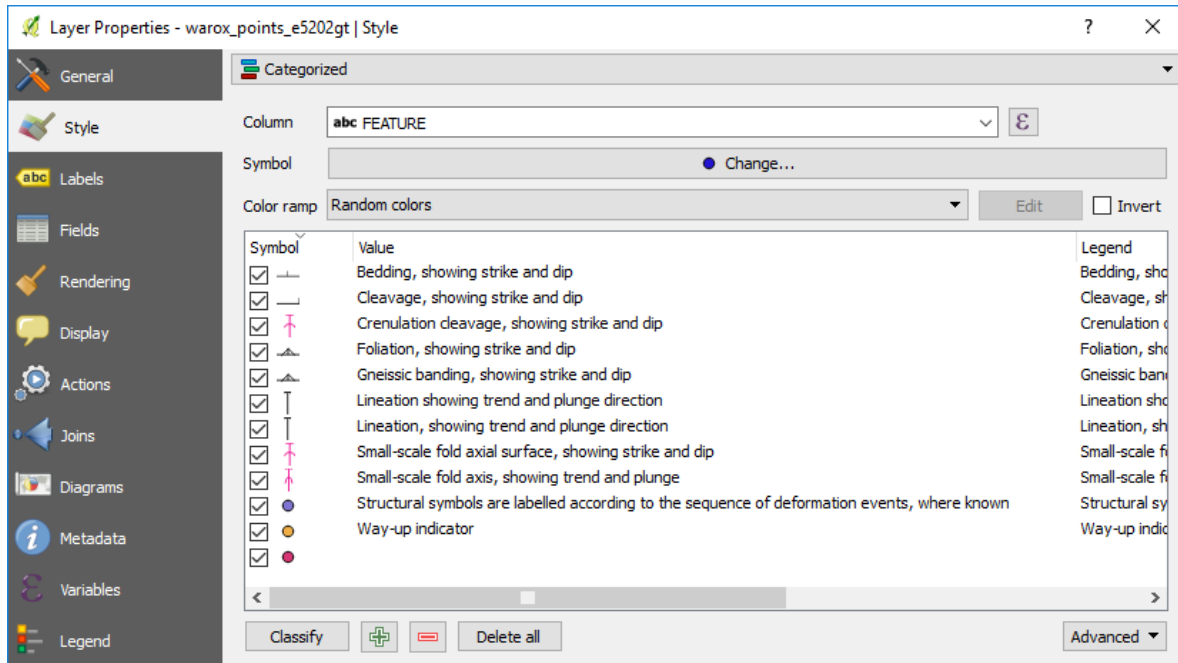
Another option for importing csv data is to load into Excel and check the field types for each field before importing. Excel files are imported using the “Spreadsheet Layers” plugin. This is found under the Layer > Add Layer > “Add spreadsheet layer” menu. It is very important to check the data is being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

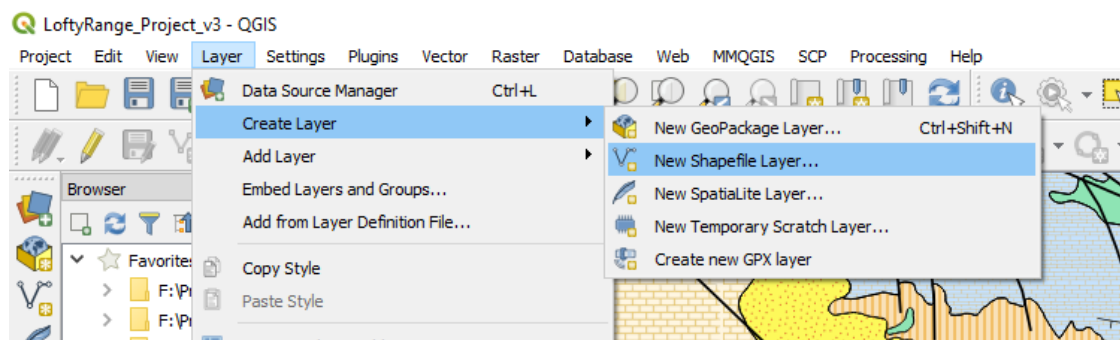
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
	X	Y	AREA	PERIMETER	GEOPNT	GEOPNT	FEATURE	TYPE	STRIKE	DIP_DIR	DIP	PLUNGE	TREND	RANK	VERGENCE	SYMBOL	JNCODE	
2	128.011	-16.509	0	0	1	1	Bedding, :inclined		45	315	58	0	0	0	0	16 4564;Bedding, showing st		
3	128.0262	-16.5084	0	0	2	2	Small-scal minor ant		0	0	0	0	0	38	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		

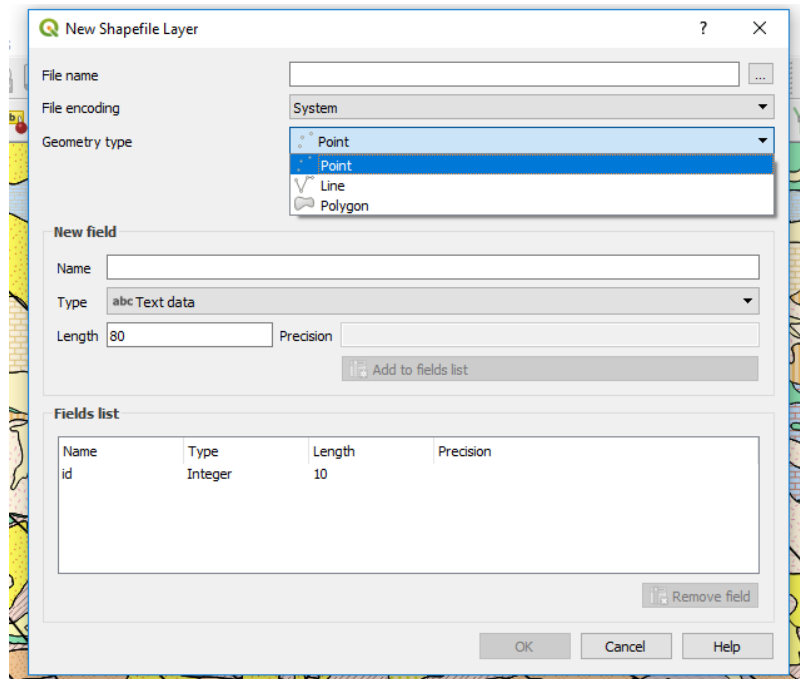


Below is an example of the “categorised” features of the WAROX data for the GSWA Lissadell 250k map sheet with features manually changed by clicking on each symbol. Once this has been done, remember to **save** the symbols by using the “Style” button and “Save style” to a QGIS qml style file (e.g. GSWA_WAROX.qml). 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.



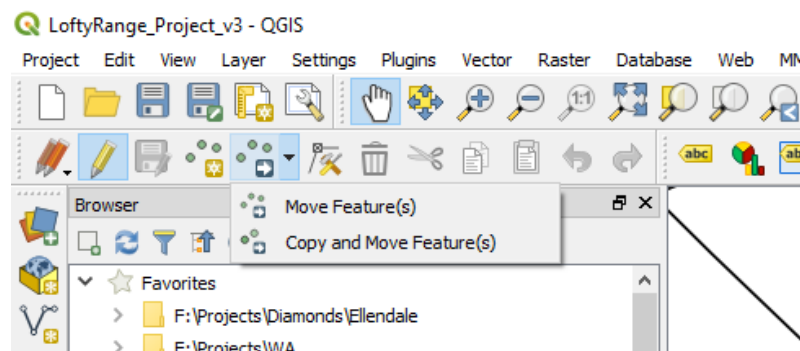
To create a new empty points layer, use the menu item Layer > Create Layer > New Shapefile Layer and select a point layer type (**very important to check the geometry type! And CRS**). Add the required data columns and data types (text, integer, decimal number, date) to attach to each point. Remember 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 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). Note that 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 “Update Coordinates” option in the “Attribute Table”.



Move tool highlighted in editing toolbar.

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.



FieldLocs_2016.shp :: Features Total: 29, Filtered: 29, Selected: 0

1.2 Easting

abc Point
abc Datum
abc Zone
1.2 Easting
1.2 Northing
1.2 RL
abc ObsType
1.2 STRK_PLUNG
1.2 Dip
abc Comments

	Datum	Zone	Easting	Northing	RL	ObsType	STRK_PLUNG	Dip	Comments	
	GDA94	50	397480.0000000...	6741475.000000...	318.0000000000...				Pisolithic laterite o...	N
	GDA94	50	397560.0000000...	6741440.000000...	313.0000000000...	Bedding	45.00000000000...	35.00000000000...	Outcrop of large ...	N
	GDA94	50	397583.0000000...	6741378.000000...	309.0000000000...	Joint	335.0000000000...	75.00000000000...	Breccia, vein qtz ...	Y
	GDA94	50	397583.0000000...	6741378.000000...	309.0000000000...					Y
	GDA94	50	397643.0000000...	6741345.000000...	305.0000000000...	FoldAxis	25.00000000000...	45.00000000000...	Breccia, smaller c...	Y
6	GB05	GDA94	50	397643.0000000...	6741345.000000...					Y
7	GB06	GDA94	50	397470.0000000...	6741470.000000...	Bedding	50.00000000000...	35.00000000000...	Top of pisolite hill...	N

Show All Features

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. In your field data file, add extra columns in the file for "file location" (path) and file name, so that QGIS can find the file and display it.

There are a few of ways to display photos at points. One is using the Import Photos plugin, the second is going via the Layer Properties > Actions (thanks to Mike Erceg for explaining this process), and the other is by using the eVis plugin. The last two options require the full path to the file to be opened to be determined.

If your photos are geo-tagged, i.e. they have their coordinate locations imbedded in the file, then the easiest option is to use the Import Photo 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 has an in-built gps, so all photos are automatically geo-tagged.

To use the plug-in, select the directory where the photos are located, 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.

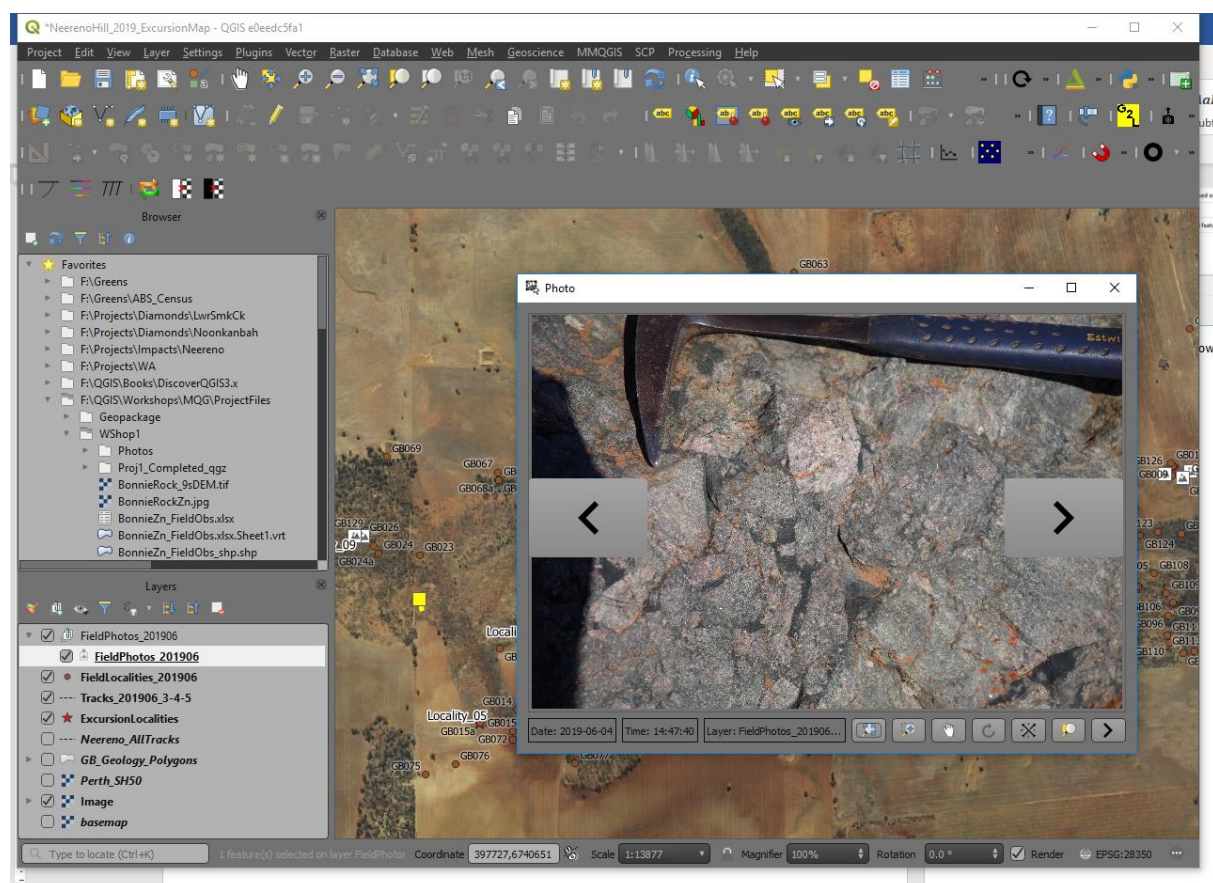
ImportPhotos

Input folder location: F:/Projects/Impacts/Neereno/FieldTrip/201906/Photos Browse...

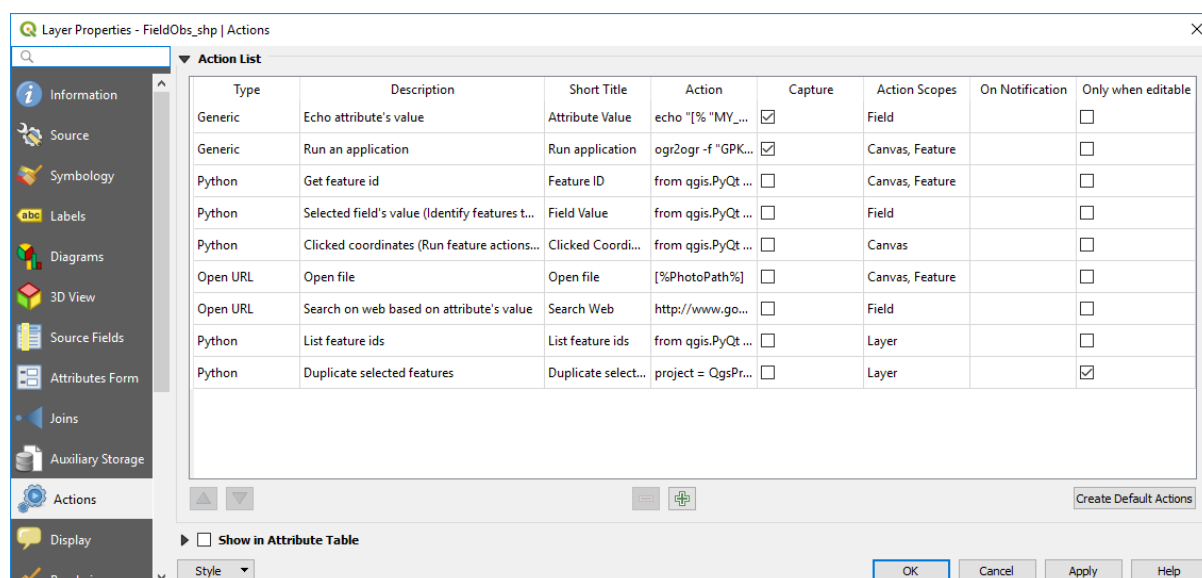
Output file location: F:/Projects/Impacts/Neereno/FieldTrip/201906/Photos/FieldPhotos_201906.shp Browse...

Load style (optional): e.g. C:/Users/Grant/AppData/Roaming/QGIS/QGIS3/profiles/default/python/plugins/ImportPhotos/photos.qml Browse...

OK Close



The second 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.

Edit Action

Type: Open ☐ Capture output

Description:

Short Name:

Icon:

Action Scopes

☒ Feature Scope

☐ Layer Scope

☒ Canvas

☐ Field Scope

Action Text

The action text defines what happens if the action is triggered.
 The content depends on the type.
 For the type *Python* the content should be python code
 For other types it should be a file or application with optional parameters

1

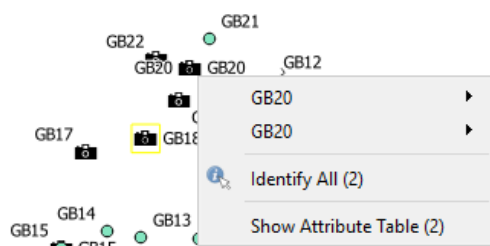
abc PhotoPath

Execute if notification matches

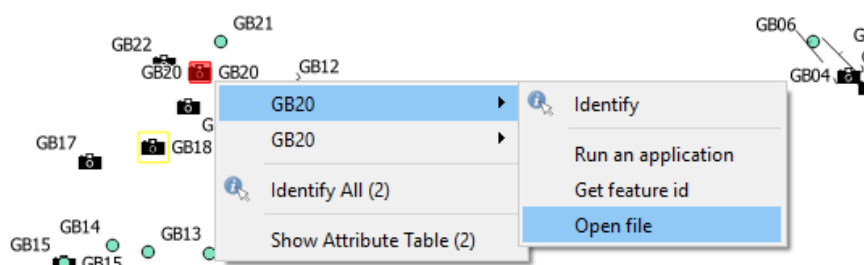
☐ Enable only when editable

In the dropdown box near the bottom of the box, select the field with the photo location (full file path) and click “Insert” to put the path into the Action Text window.

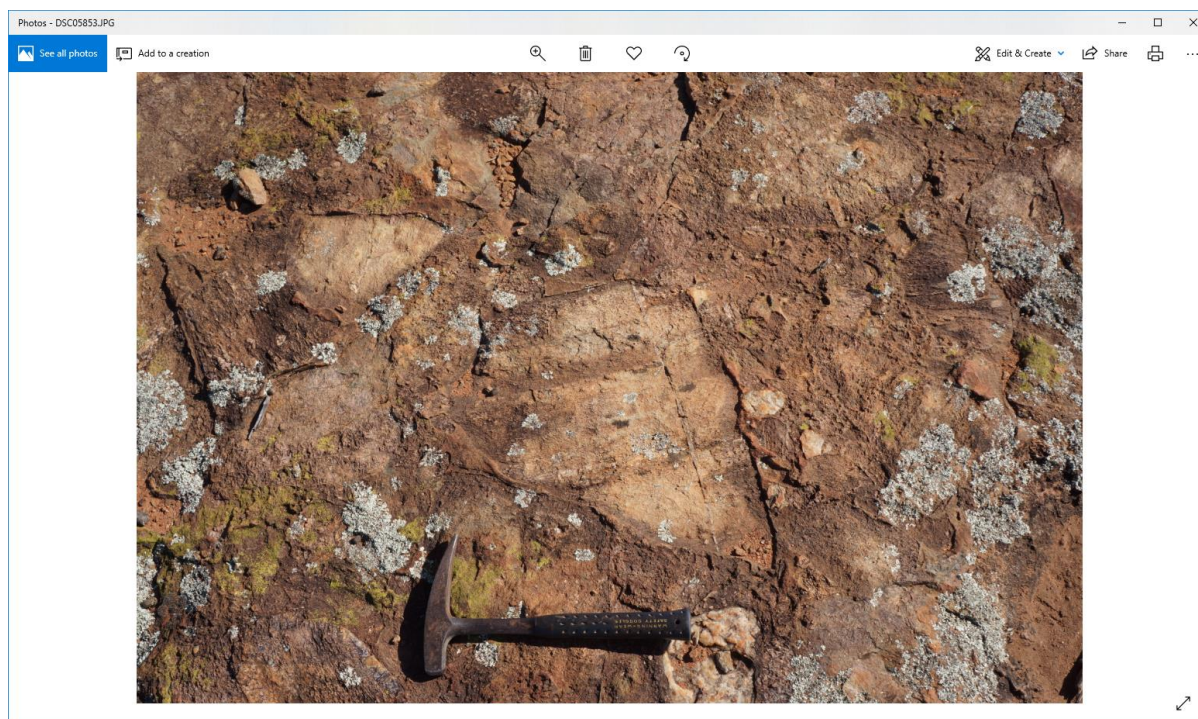
With the “Identify Features” activated for the cursor, right click on a point with a photo and the following will be displayed over the point.



Note there are two photos at this location.

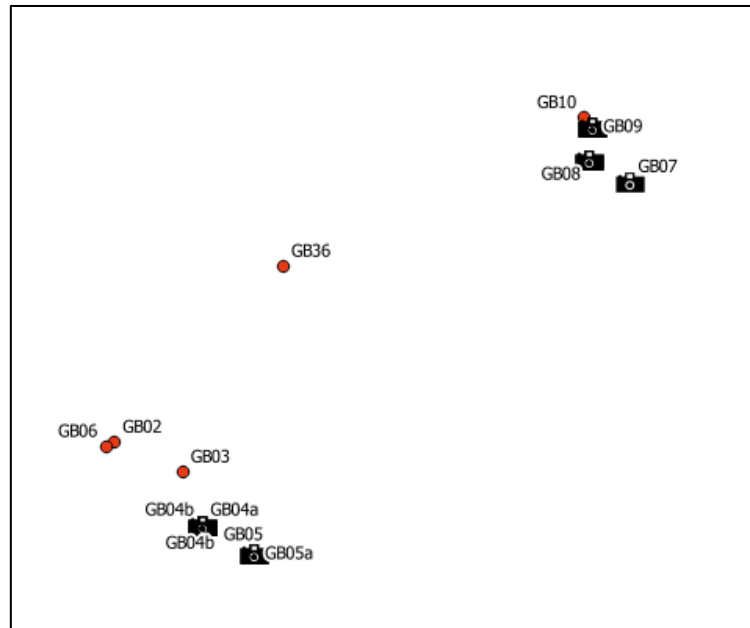


Select the “Open File” option and the photo will be displayed.





The third option for displaying photos is using the eVis plug-in which can also be used to display documents that are linked to points. eVis is located under the Database menu option on the top window menu. See the eVis documentation (evis_user_guide_v1.1.pdf) for detailed information on specifications of file locations and specifying the location of the pdf reader (if required). It is recommended that you also add a column to advise the user if there are photos available – such as a column named something like “PhotoYN”, with a yes/no answer so that you can display an icon indicating a photo is available for that location. Use the “Categorise” layer property option to show the yes-no options and change the “yes” data points to small camera icons.



Example file showing relative file location for outcrop photographs.

FieldLocs_2016.shp :: Features total: 72, filtered: 72, selected: 0

abc Point	Point	Datum	Zone	RL	Sample	Comments	Photo	PhotoFile	HasPhoto	Easting	Northing
3	GB27	GDA94	50	286		Large pavement ...	#5859-5863	\\images\\Kinyorra\\DSC05863.JPG	Yes	394846.00	6741567.00
4	GB27	GDA94	50	286		Large pavement ...	#5859-5863	\\images\\Kinyorra\\DSC05862.JPG	Yes	394846.00	6741567.00
5	GB27	GDA94	50	286		Large pavement ...	#5859-5863	\\images\\Kinyorra\\DSC05861.JPG	Yes	394846.00	6741567.00
6	GB27	GDA94	50	286		Large pavement ...	#5859-5863	\\images\\Kinyorra\\DSC05860.JPG	Yes	394846.00	6741567.00
	GB27	GDA94	50	286		Large pavement ...	#5859-5863	\\images\\Kinyorra\\DSC05859.JPG	Yes	394846.00	6741567.00

Show All Features

It is recommended to use “relative” file paths (select “Path is Relative” in the eVis options panel), and provide the base directory, so that if you move files to a new directory, you can update the base directory and QGIS will find the files. Check the tick boxes on the “File Path” and “Relative Path” option so that QGIS remembers these settings for the other photos in the file.



Event Browser - Displaying Records 01 of 01
?
X

Display
Options
Configure External Applications

File path
Attribute containing path to file PhotoFile
☐ Path is relative ☐ Remember this Reset

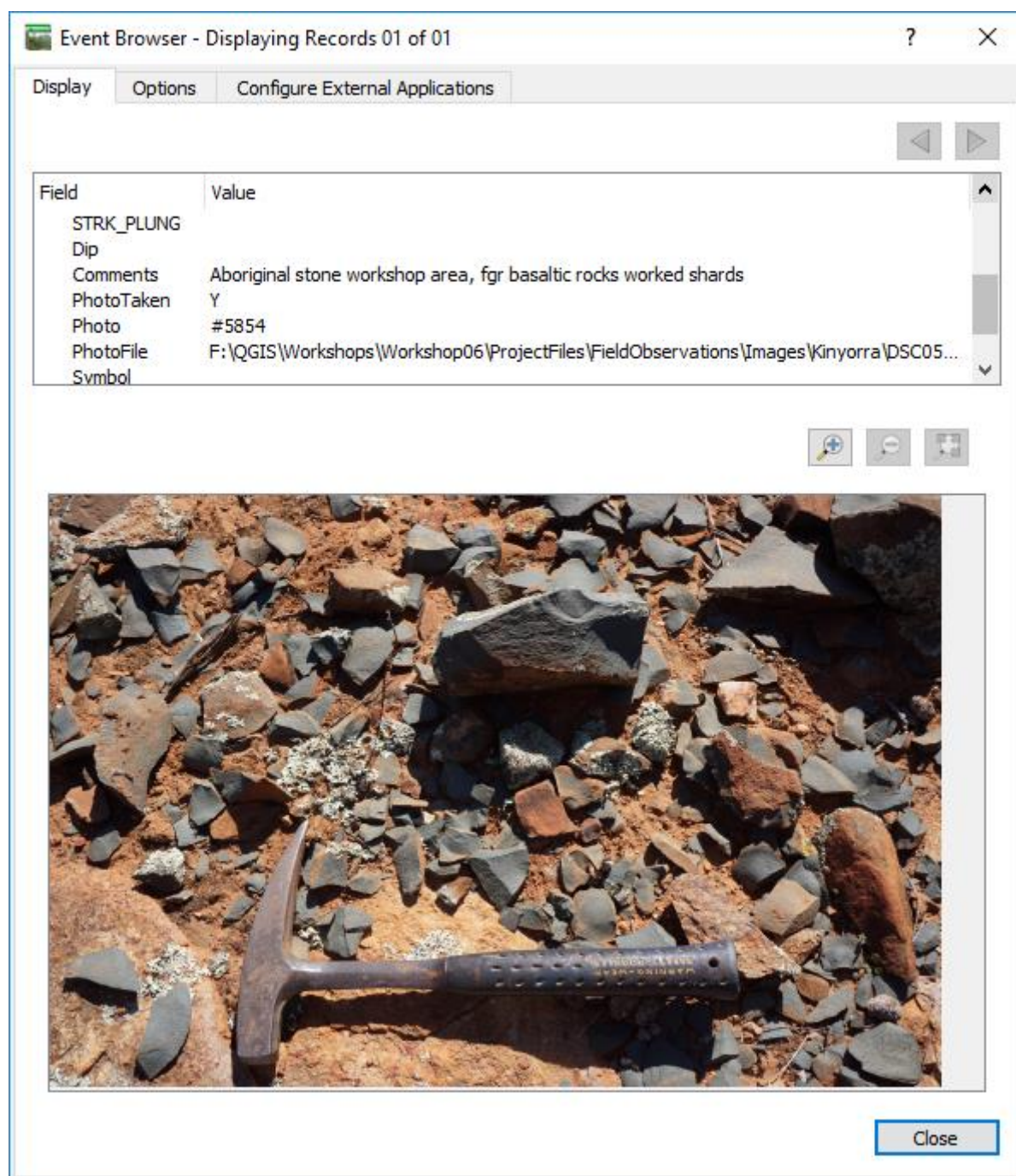
Compass bearing
Attribute containing compass bearing Point
☐ Display compass bearing ☐ Remember this Reset

Compass offset
☐ Manual 0.0
☐ From Attribute Point ☐ Remember this Reset

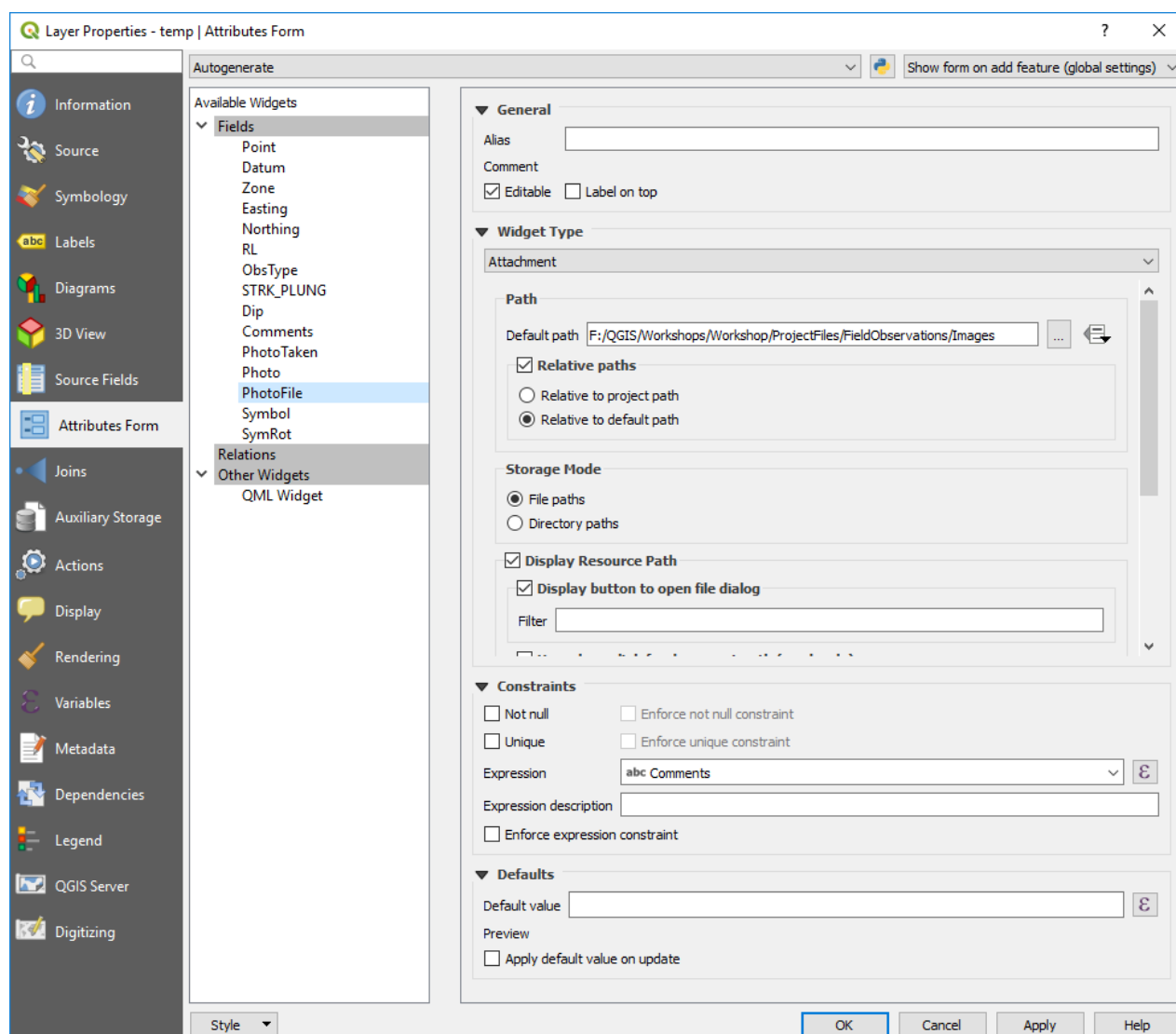
Relative paths
The base path or url from which images and documents can be "relative"
Base Path C:/Users/Grant/ ☐ Remember this Reset
☐ Replace entire path/url stored in image path attribute with user defined Base Path (i.e. keep only filename from attribute) ☐ Remember this Reset
☐ Apply Path to Image rules when loading docs in external applications ☐ Remember this Reset

Restore Defaults
Save

Other file types can also be linked, for example, pdf report files can also be attached to observation points (see the eVis user guide for more information).



A fourth method to display photos is as follows using a widget in Layer Properties > Attributes Form. Select the field with the file location, e.g. "PhotoFile" field, then widget type "Attachment". Enter the default path to the image folder, tick "Relative paths" and "Relative to default path" option.



Scroll down the window to display “Integrated Document Viewer” and select “Image”. Leave the sizes to Auto.



Layer Properties - temp | Attributes Form

Autogenerate

Show form on add feature (global settings)

Available Widgets

- Fields
 - Point
 - Datum
 - Zone
 - Easting
 - Northing
 - RL
 - ObsType
 - STRK_PLUNG
 - Dip
 - Comments
 - PhotoTaken
 - Photo
 - PhotoFile
 - Symbol
 - SymRot
- Relations
- Other Widgets
 - QML Widget

Style

General

Alias

Comment

☒ Editable ☐ Label on top

Widget Type

Attachment

☒ Display Resource Path

☒ Display button to open file dialog

Filter

☐ Use a hyperlink for document path (read-only)

☐ Display the full path

Integrated Document Viewer

Type: Image

Width: Image

Height: Auto

Specify the size of the preview. If you leave it set to Auto, an optimal size will be calculated.

Constraints

☐ Not null ☐ Enforce not null constraint

☐ Unique ☐ Enforce unique constraint

Expression: abc Comments

Expression description

☐ Enforce expression constraint

Defaults

Default value

Preview


☐ Apply default value on update

OK Cancel Apply Help

Apply the changes. In the map window, use the identify icon to click on a point with a photo, then in the identify results window, open the form view and re-size 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.



temp - Feature Attributes

Point	GB22
Datum	GDA94
Zone	50
Easting	395625.0000000000000000
Northing	6741413.0000000000000000
RL	308.0000000000000000
ObsType	Photo
STRK_PLUNG	NULL
Dip	NULL
Comments	Aboriginal stone workshop area, fgr basaltic rocks worked shards
PhotoTaken	Y
Photo	#5854
	Kinyorra\DSC05854.JPG
PhotoFile	
Symbol	NULL
SymRot	NULL

OKCancel



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.

New Shapefile Layer

File name: F:\QGIS\QGIS3\LinesTemp.shp

File encoding: System

Geometry type: Line

New field

Name:

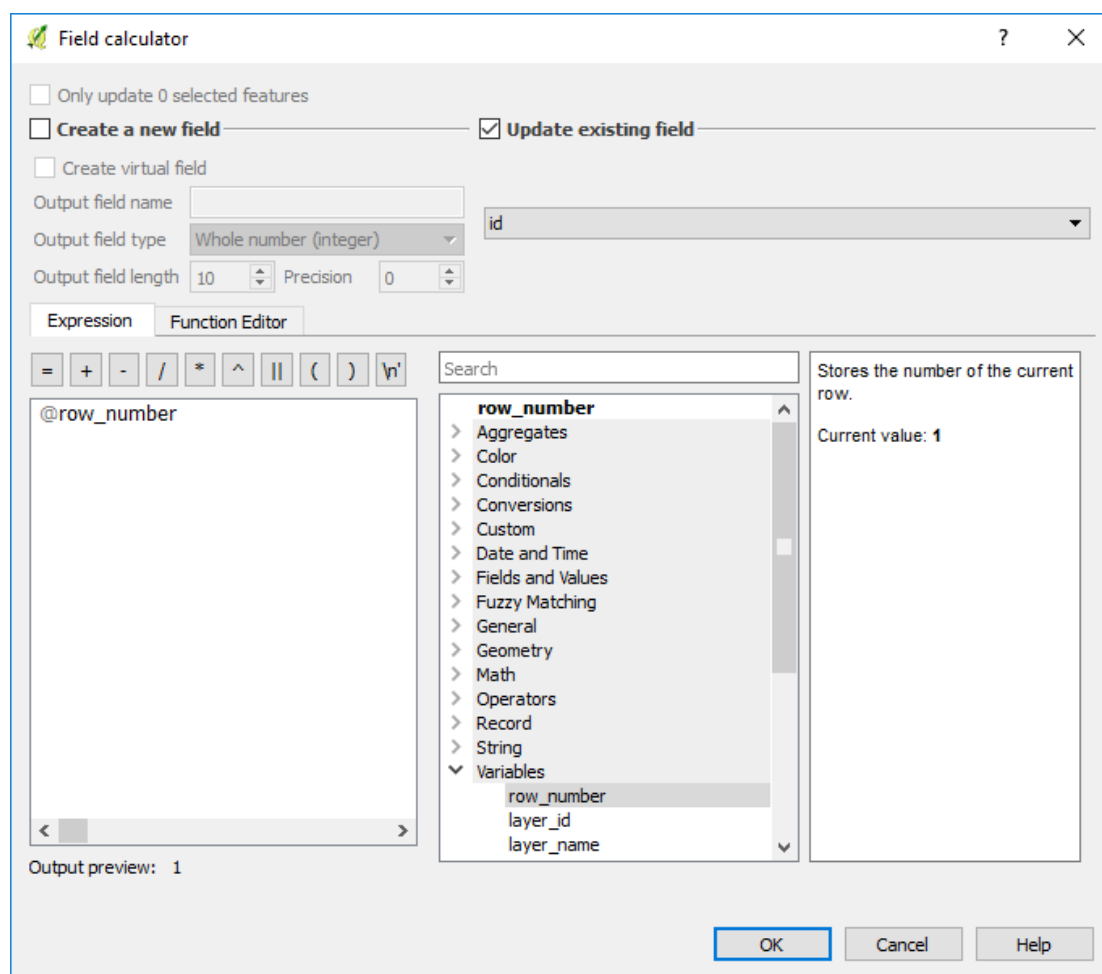
Type: abc Text data

Length: 80 Precision:

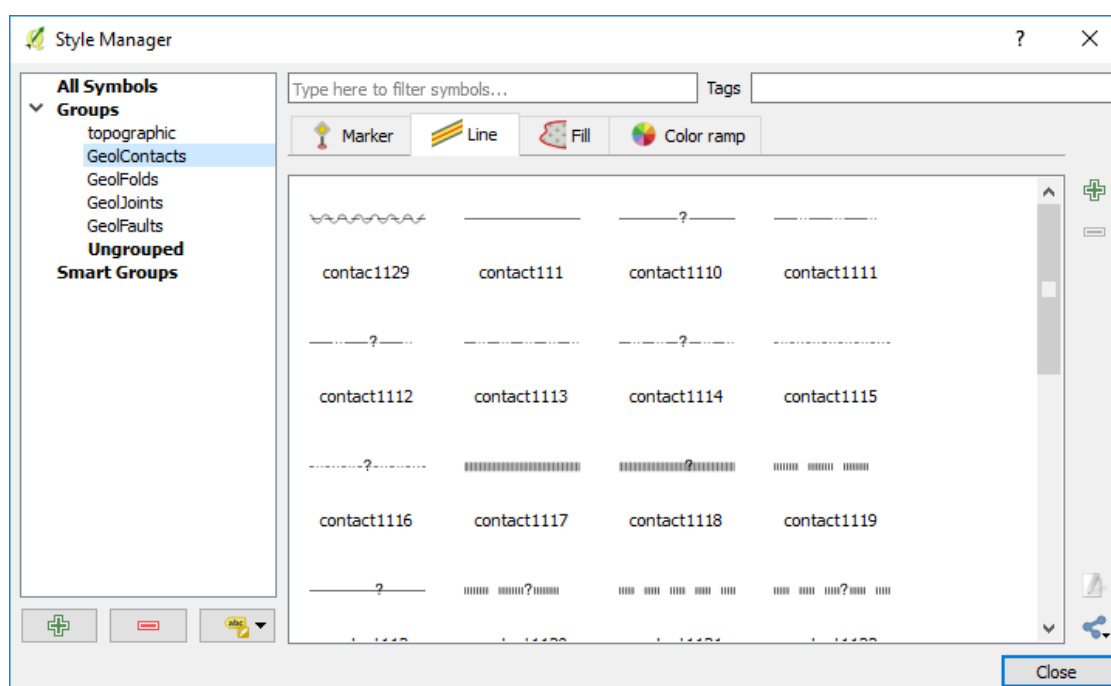
Fields list

Name	Type	Length	Precision
id	Integer	10	
Type	String	80	

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.



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.



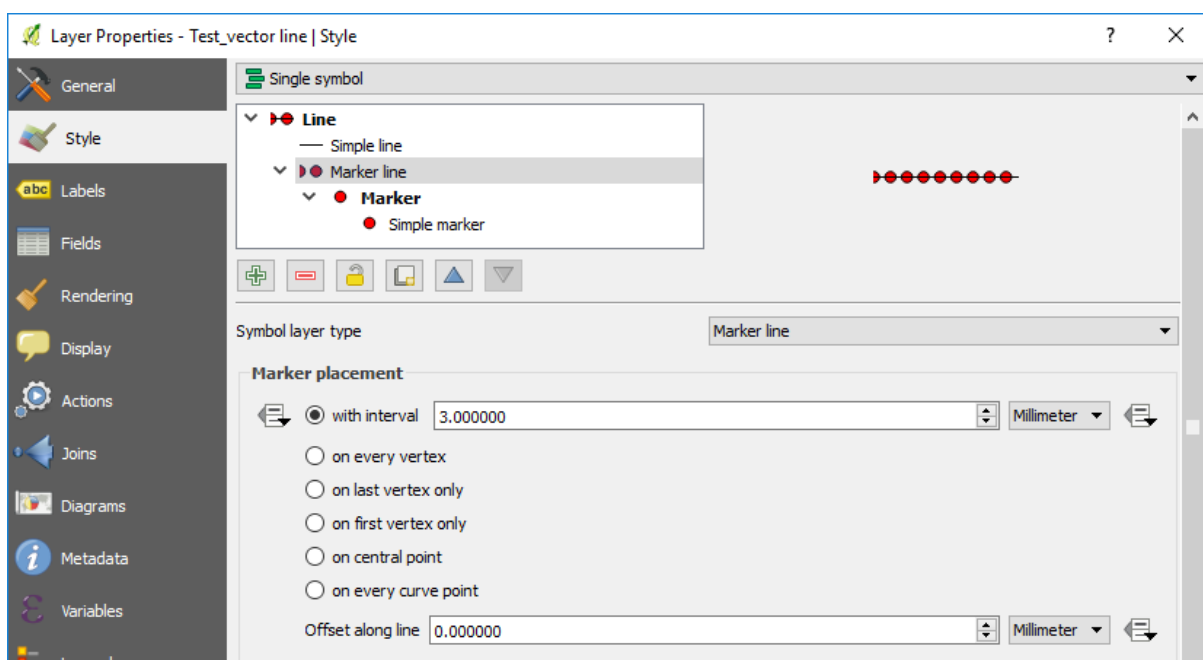


Contact the author if you would like to download these style files for contacts, folds, joints or faults which are based on the USGS symbol sets.

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

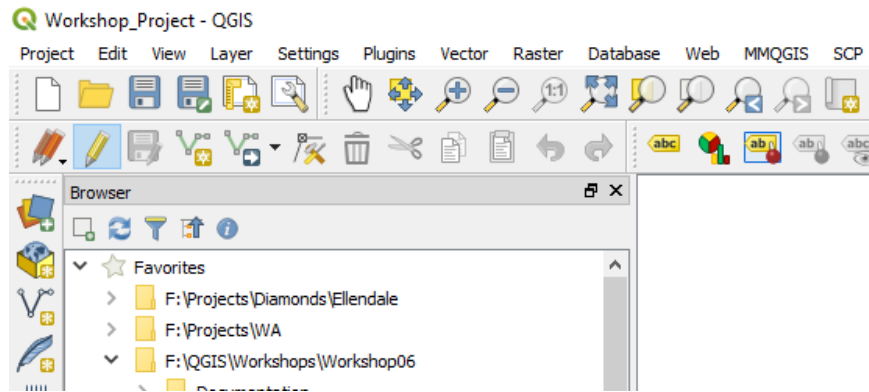
Line styles can also be created directly via the Style tab of the layer menu. Add an extra layer (using the green plus button) to combine lines and markers. There are a large number of styles and options to choose from. Remember to save the style using a qml or “Save as Default” option when finished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

See the QGIS User Manual here <https://docs.qgis.org/testing/pdf/en/QGIS-testing-UserGuide-en.pdf> for up-to-date information on editing. The Testing Version applies to v 3.6.



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.

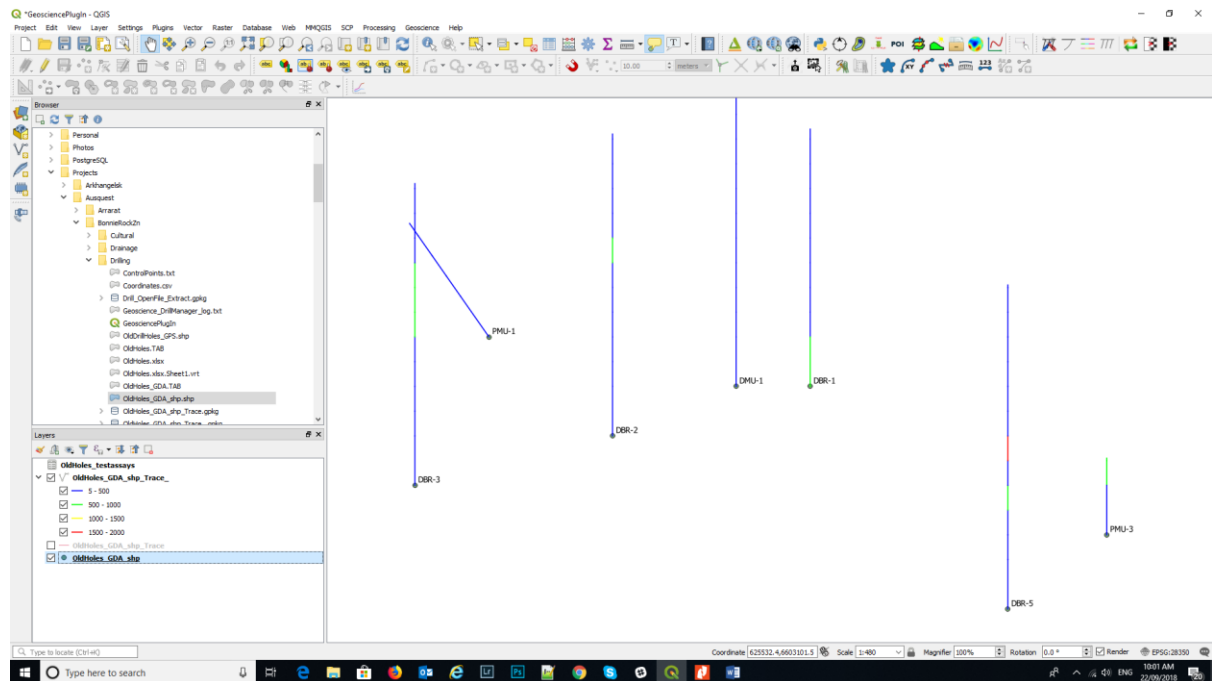
The “Geoscience” plugin that has recently been updated (thanks to Roland Hill) to make the plotting of drill hole traces and colour coding of the drill hole traces a bit easier. The new update allows cross sections to be created. The drill set up screen allows you to select the collar and survey files. You will need to select “Experimental” plugins in the Plugin Manager > Setting tab to be able to see this plugin. See the documentation for more details (<https://www.spatialintegration.com/geoscience-plugin-for-qgis/>).

If your tables have commonly used field names, then the plugin will pick the fields.



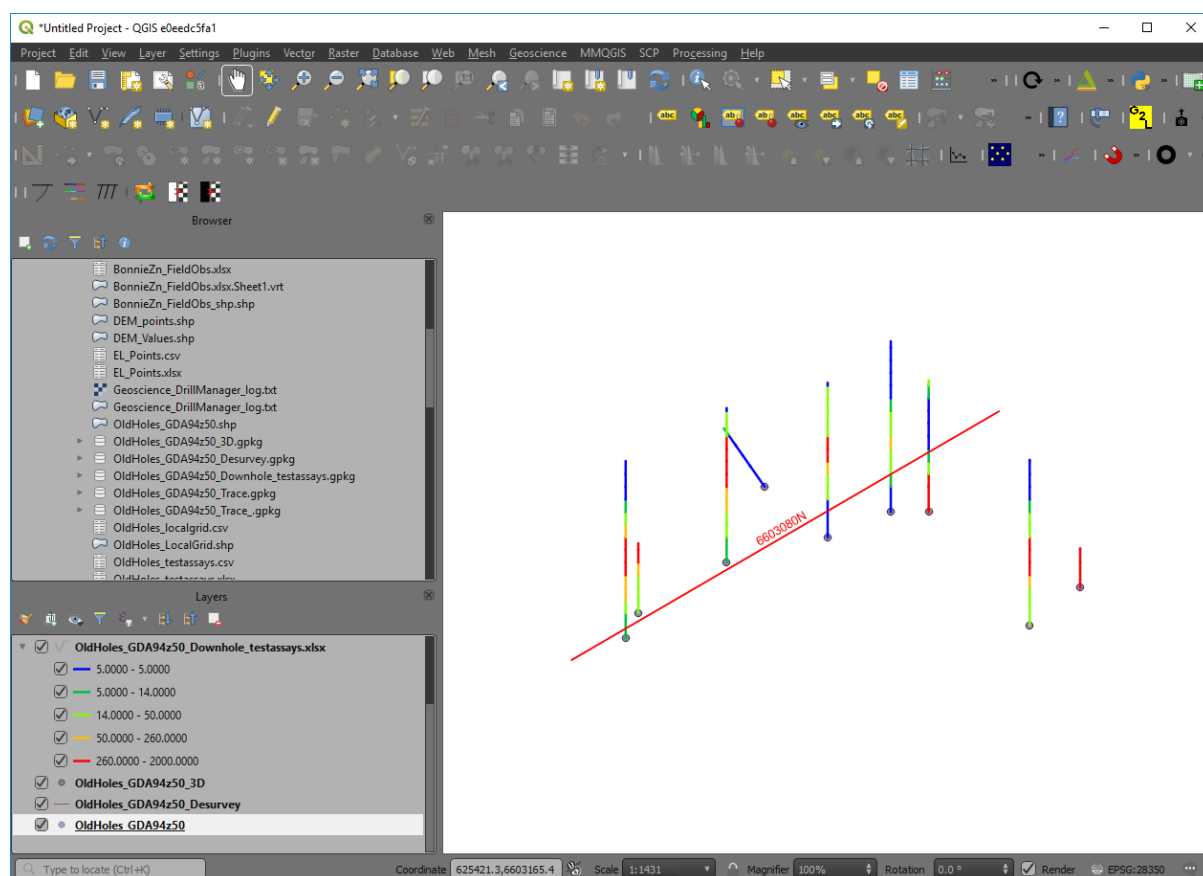
QGis v3 In Mineral Exploration

A De-survey option calculates the top and bottom points in xyz coordinates and the traces can be colour coded. The help menu for the plugin describes the work flow.

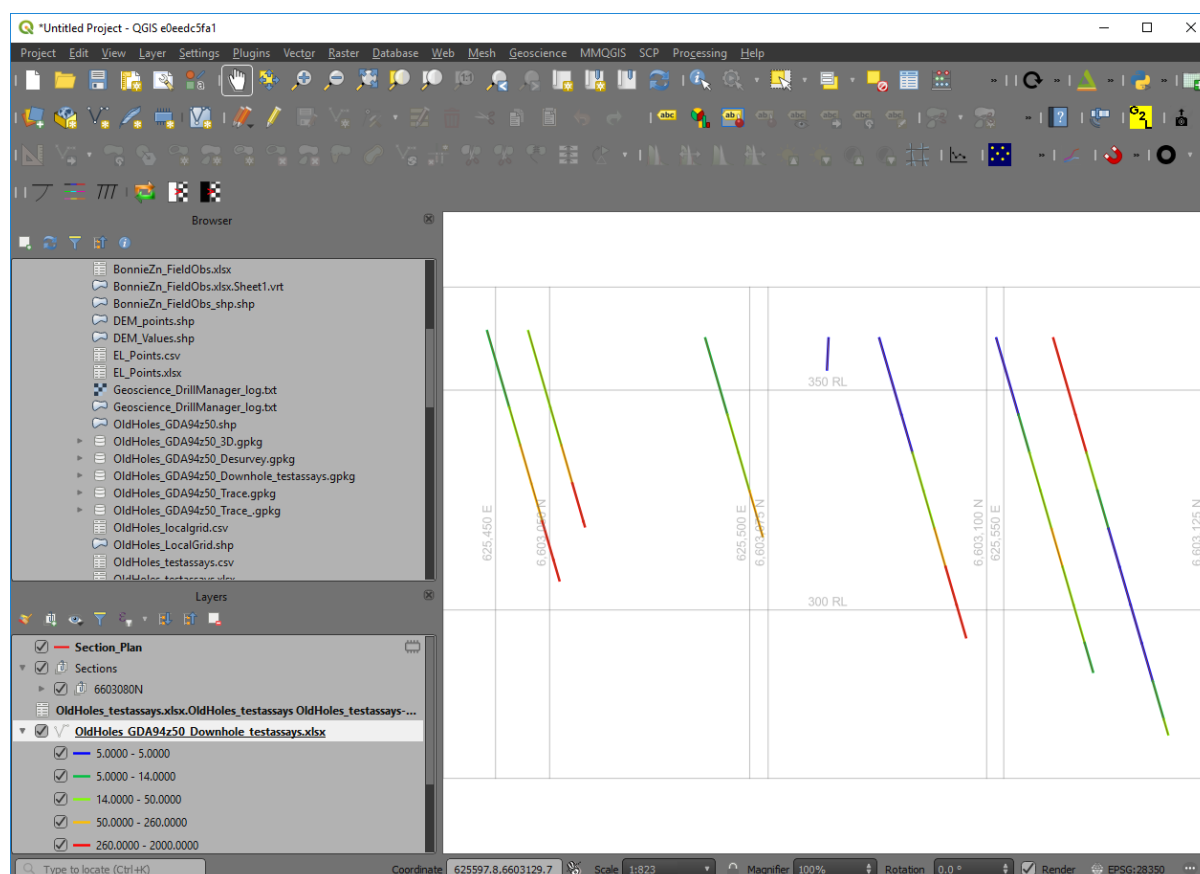


The drill hole traces can be coloured via the “Symbology” tab using any attribute. Note that when you import the downhole data, e.g. assays, make sure the “from”, “to” and assay values are recognised as numbers not text.

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.

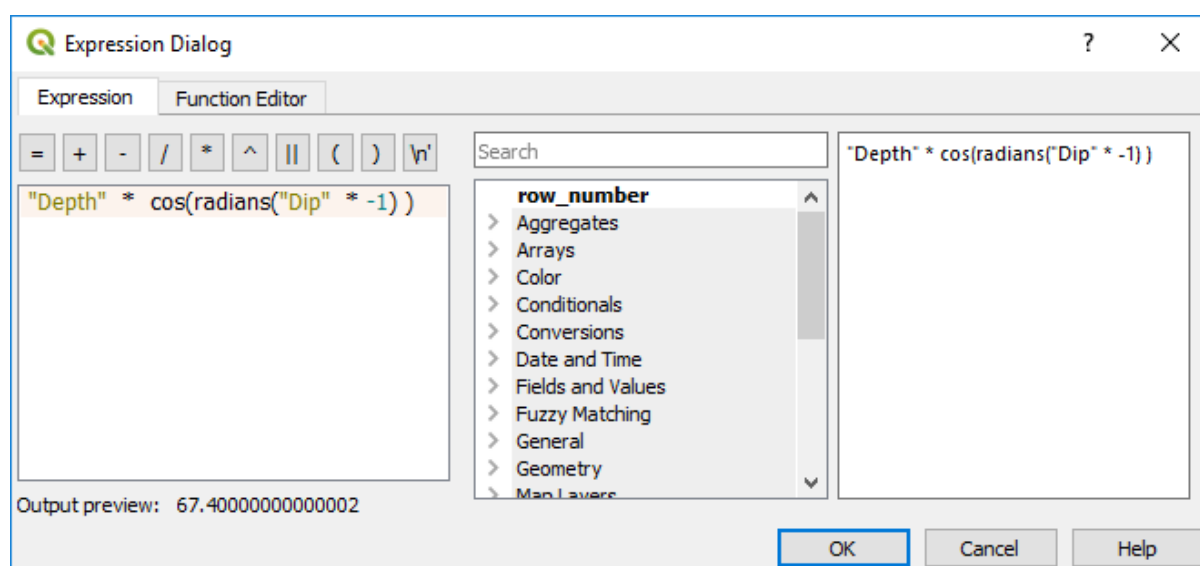


The cross section will be created in a “new” location on the map. To get back to the collar positions, right click on the collars layer and “zoom to layer”.



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).

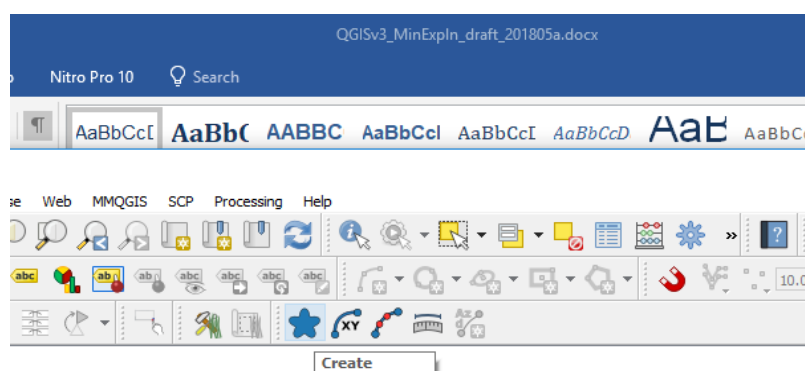


OldHoles_GDA_shp :: Features Total: 10, Filtered: 10, Selected: 0

1.2 Distance = $\text{Depth} * \cos(\text{radians}(\text{Dip} * -1))$

	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.



Create Shapes

Input points layer: OldHoles_GDA_shp

Output layer name: Shape Layer

Shape Type:

Azimuth/Bearing field: Az

Distance field: Distance

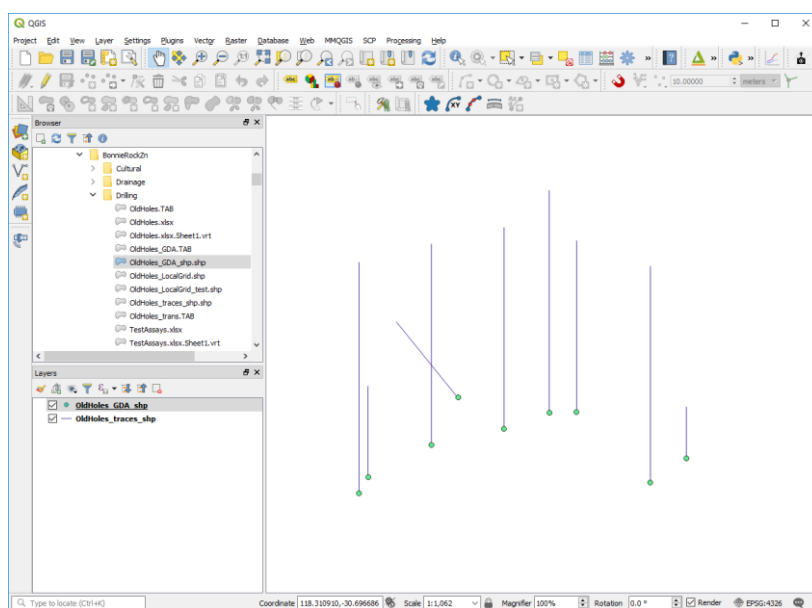
Units of distance: Meters

Default azimuth/bearing: 0.0000

Default distance: 0

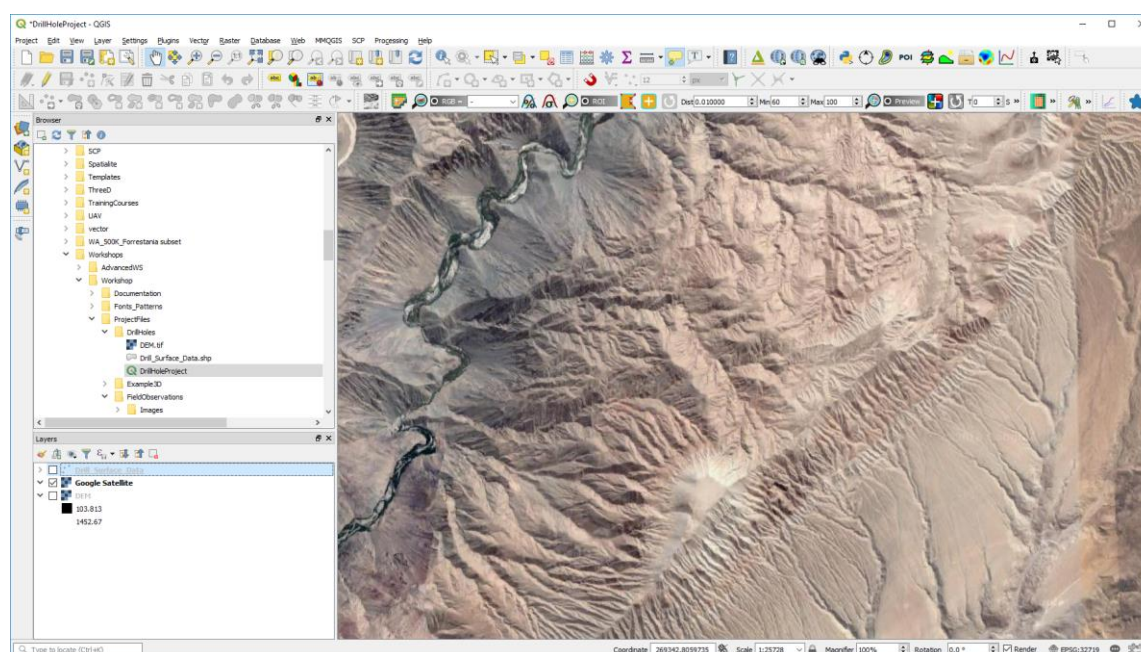
OK Cancel Apply

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.



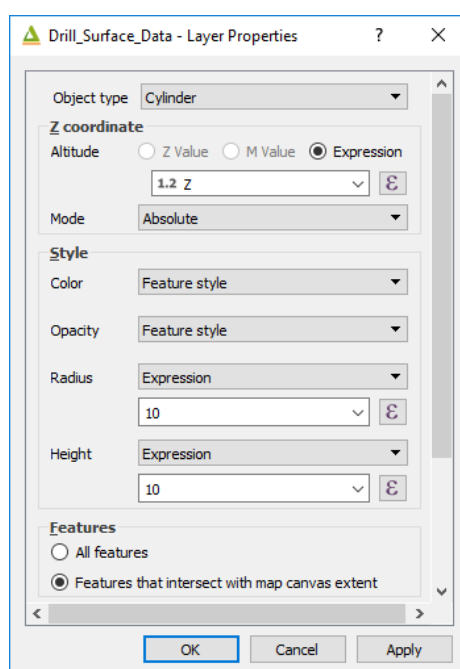
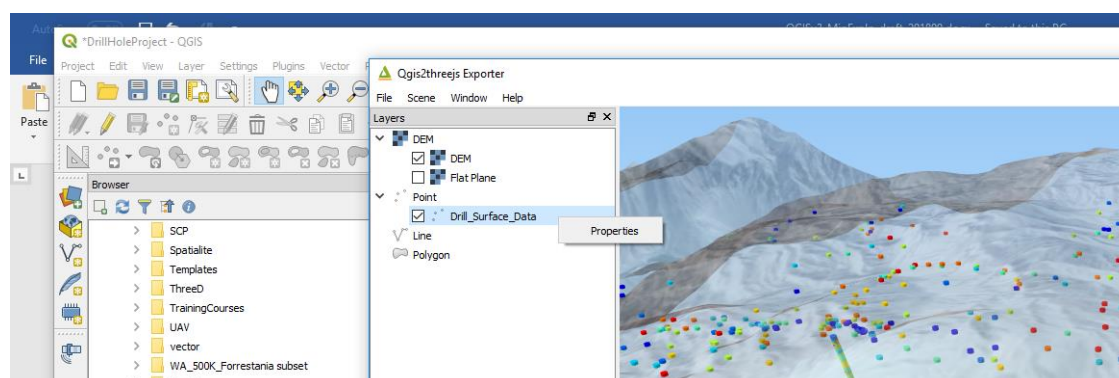
It is also possible to display drill hole data in 3D using the QGIS2threejs plugin. All that is required is to have the 3D coordinates for the sample points calculated. This is a fairly basic display option and will hopefully be superseded with the development of the drill hole and cross section module planned for the future. 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).

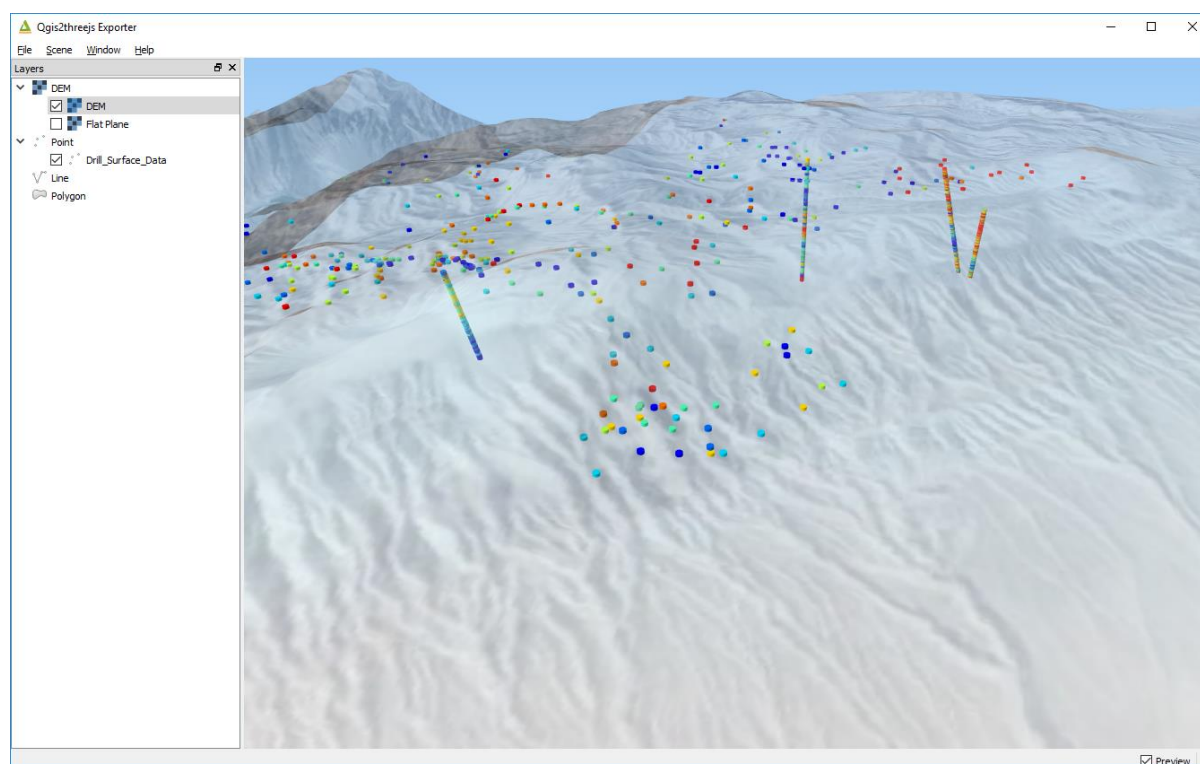




When opening the QGIS2threejs plugin, select the DEM for the elevation and right-click on the samples layer to select the z coordinate.



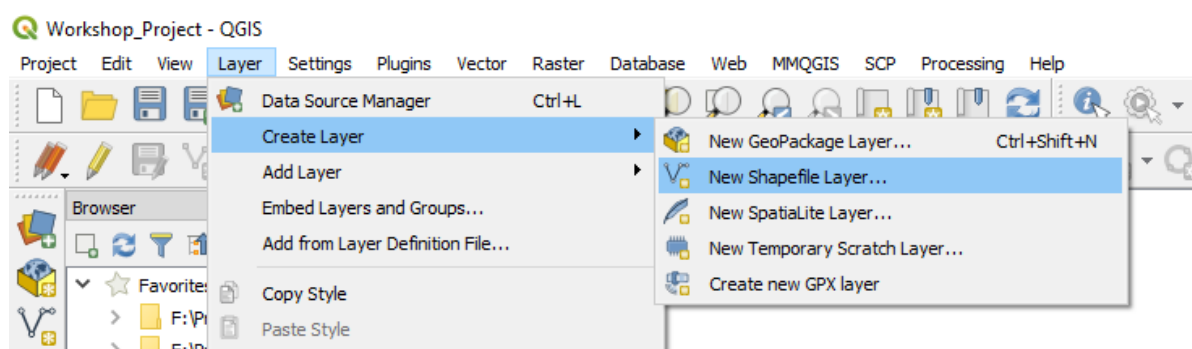
The 3D image can then be rotated and tilted as desired. The surface satellite image has been set to 30% transparency to be able to see through the surface.



It has been noted by the author that some installations using Win7 may be unstable, and it is recommended to use Win10. Always remember to save your projected regularly.

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, it 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 also remember that field names are limited to a length of 10 characters in shapefiles – but not in Geopackage files.



New Shapefile Layer

File name: F:\QGIS\QGIS3\PolyTemp.shp

File encoding: System

Geometry type: Polygon

☐ Include Z dimension ☐ Include M values

EPSG:28350 - GDA94 / MGA zone 50

New field

Name:

Type: Text data

Length: 200 Precision:

Add to fields list

Fields list

Name	Type	Length	Precision
id	Integer	10	
Code	String	80	
Lithology	String	200	

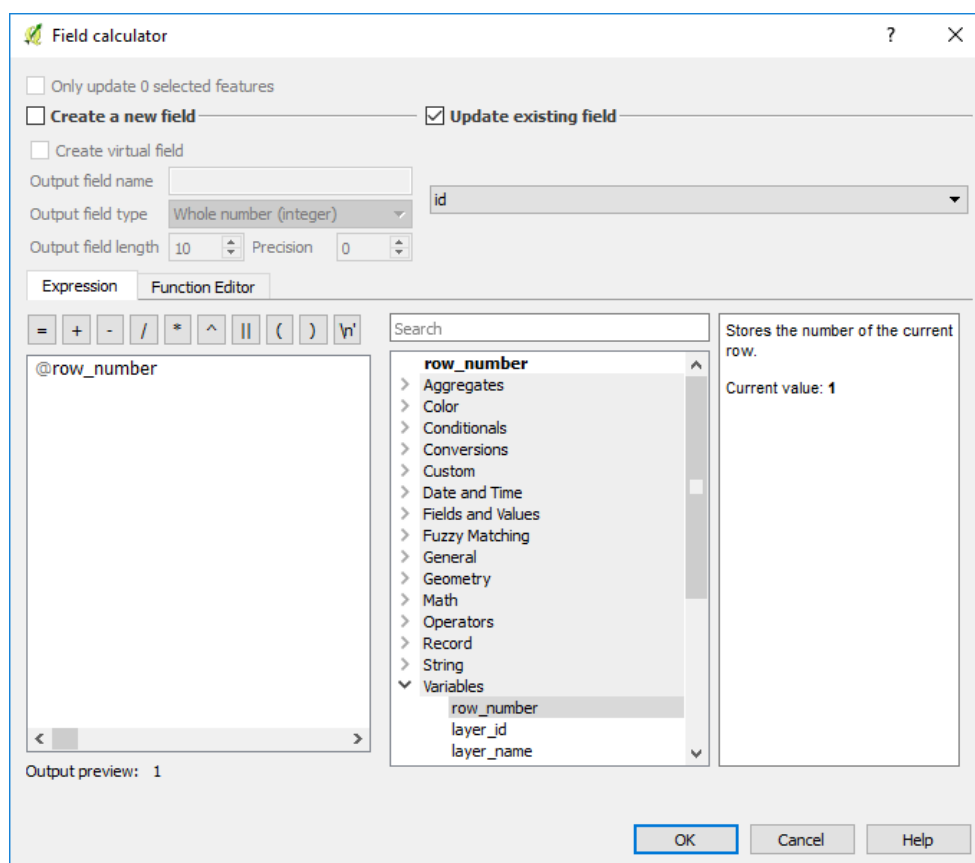
Remove field

OK Cancel Help

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). A number of 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 complete. 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 dialogue 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 dialogue 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 the mouse over the polygon when the Info Tool is activated.



geology_surface_sd5112 :: Features total: 906, filtered: 906, selected: 0

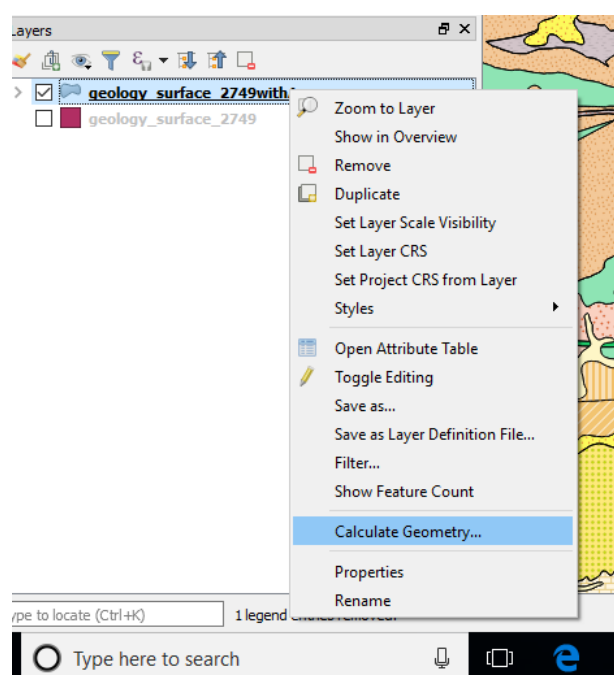
1.2 Area = \$area

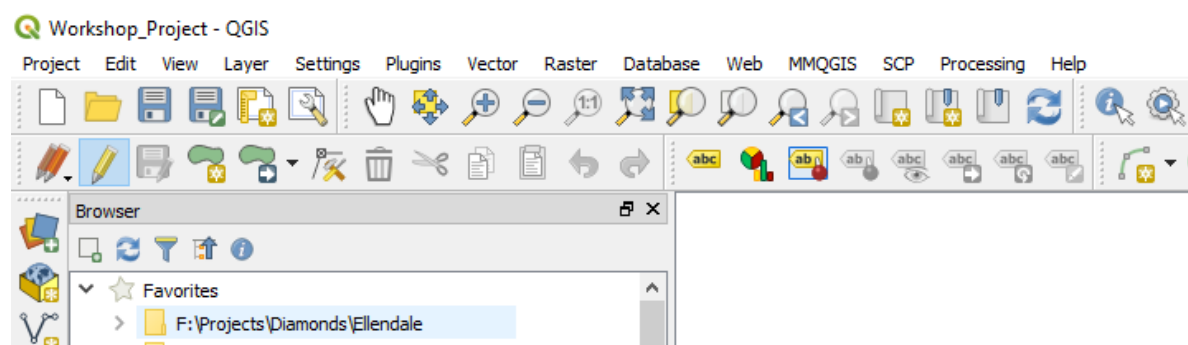
Update All Update Selected

	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
	P_kr	sd5112;P_kr	0.03

Show All Features

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.

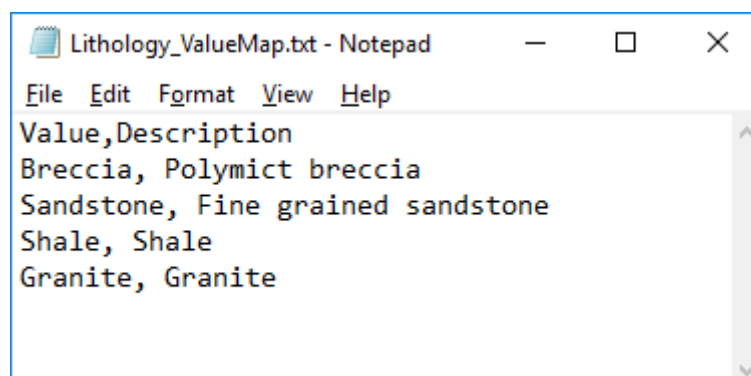




To digitise a polygon, make the layer editable and choose the “Add Feature” polygon icon (4th from the left). Click around the polygon using left mouse clicks and finish the polygon with a right mouse click. Nodes can be shifted and added-deleted using the node icon, as per the line editing options.

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.



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 ran a crowd funding campaign to get this 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.



	id	type
1	1	A
2	2	B
3	3	C
4	4	D

	id	subtype	fk
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!

Layer Properties - wells | Attributes Form

Autogenerate Hide form on add feature (global settings)

Available Widgets

- Fields
 - fid
 - type
 - subtype
- Relations

General

Alias

Comment

☒ Editable ☐ Label on top

Widget Type

Value Relation

Select layer, key column and value column

Layer

Key column

Value column

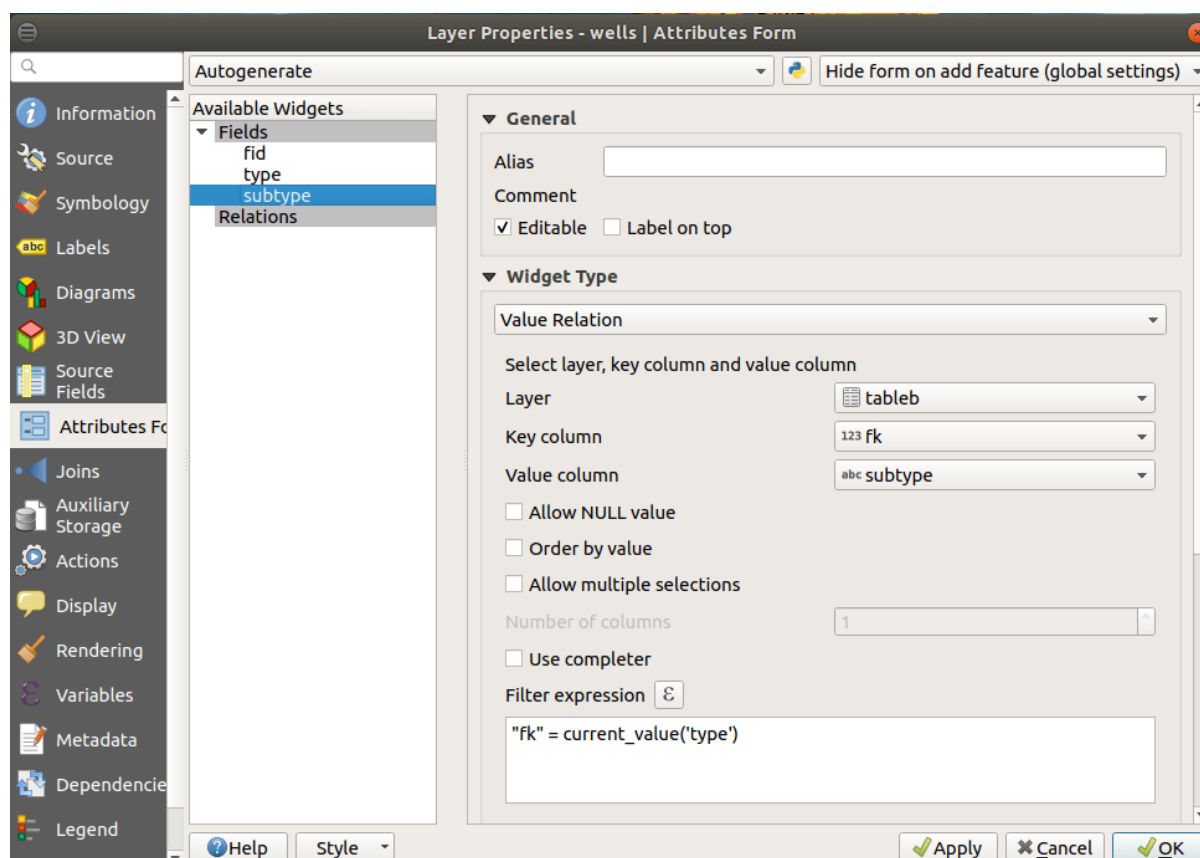
☐ Allow NULL value

☐ Order by value

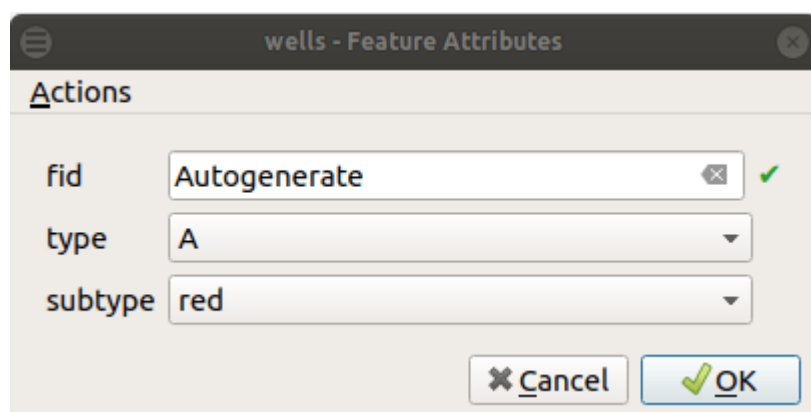
☐ Allow multiple selections

Number of columns

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.



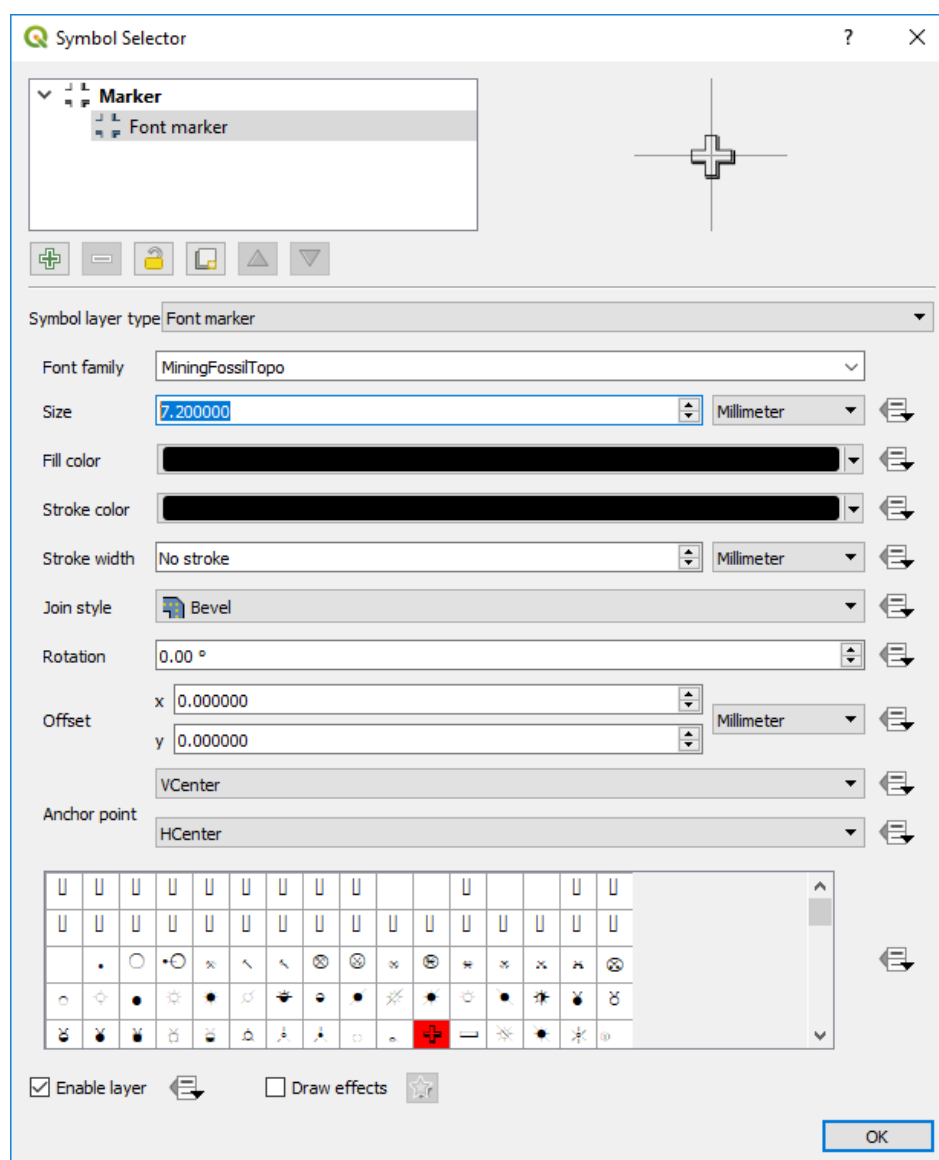
7.6 Geological Symbols and Geological Patterns

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 (<https://github.com/GISSimbology/symbols>). On Windows systems, geological symbol fonts need to be installed by right-clicking on the font file name and selecting Install.

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 can be used as well).

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. Adjust the font size to suit.



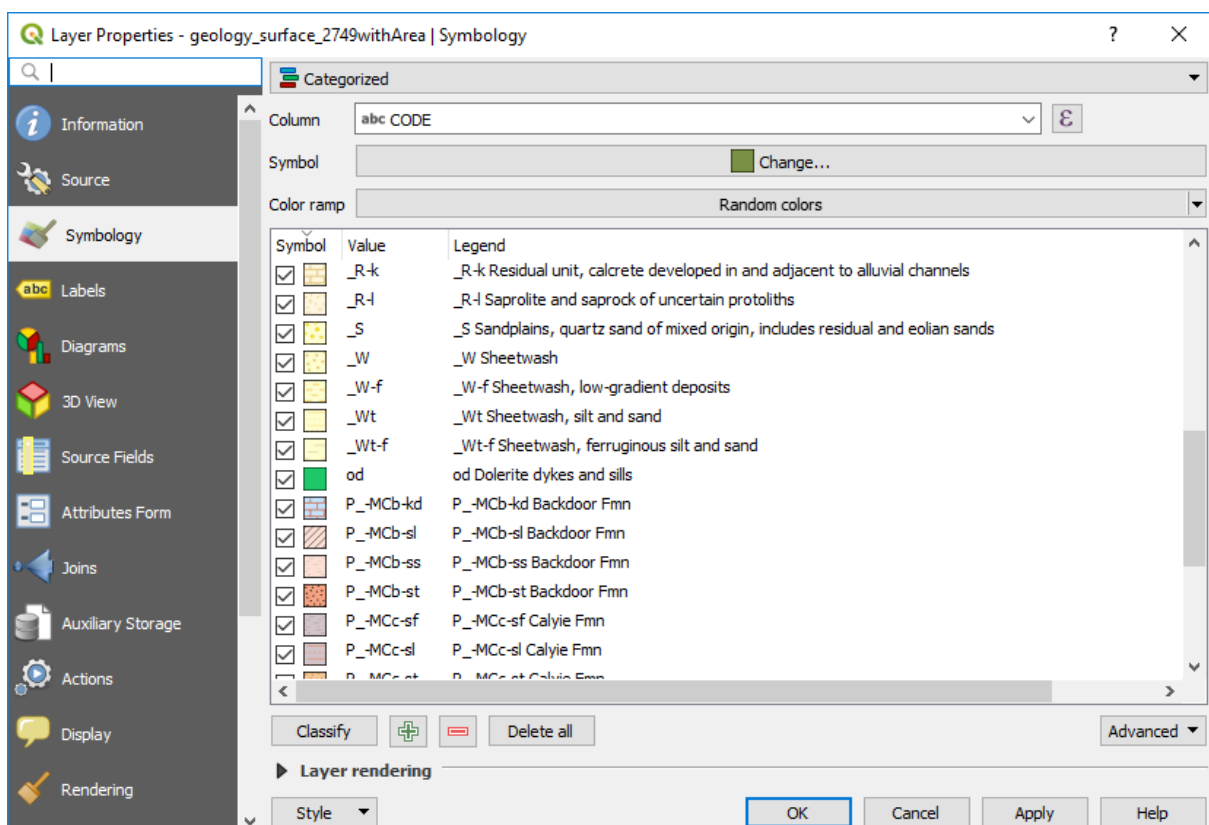


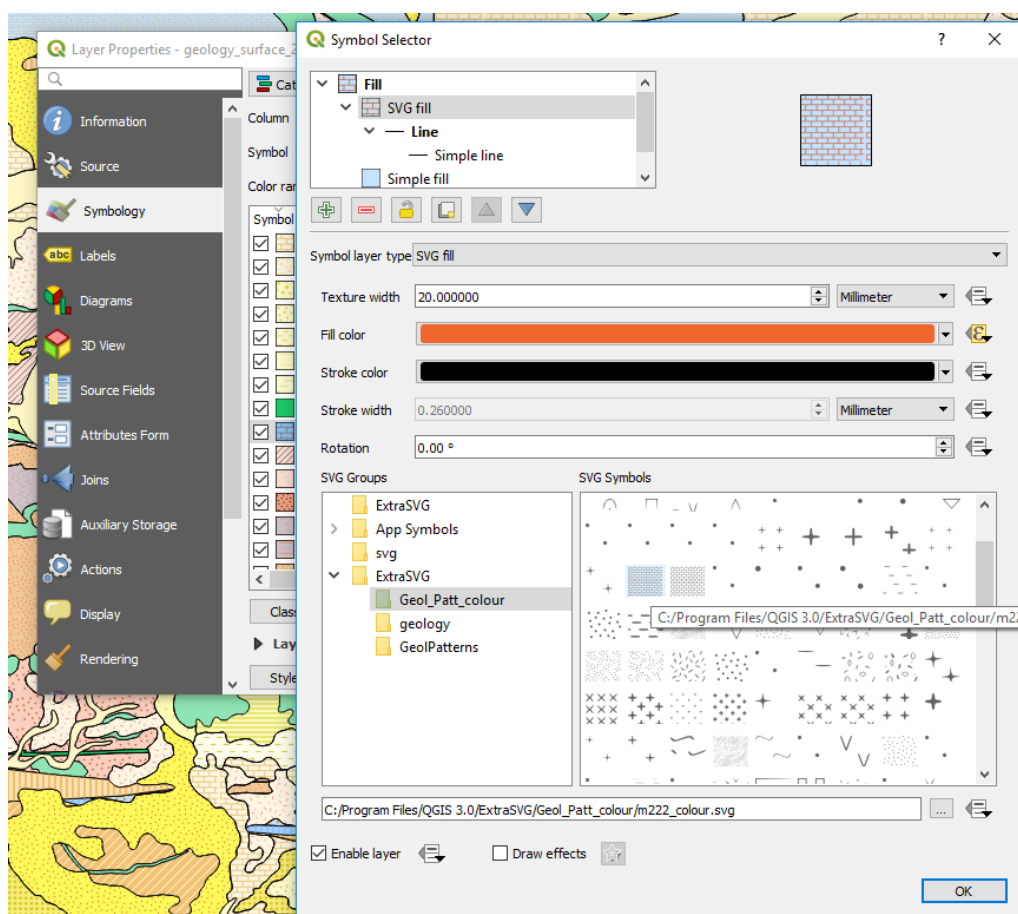
SVG Symbols and Patterns

A selection of svg geological pattern files shown in the appendix were initially sourced from Stefan Revets' page (<https://sourceforge.net/projects/qgisgeologysymbology/files/?source=navbar>) 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 <https://github.com/BC-Consulting/FGDC-4-QGIS>.

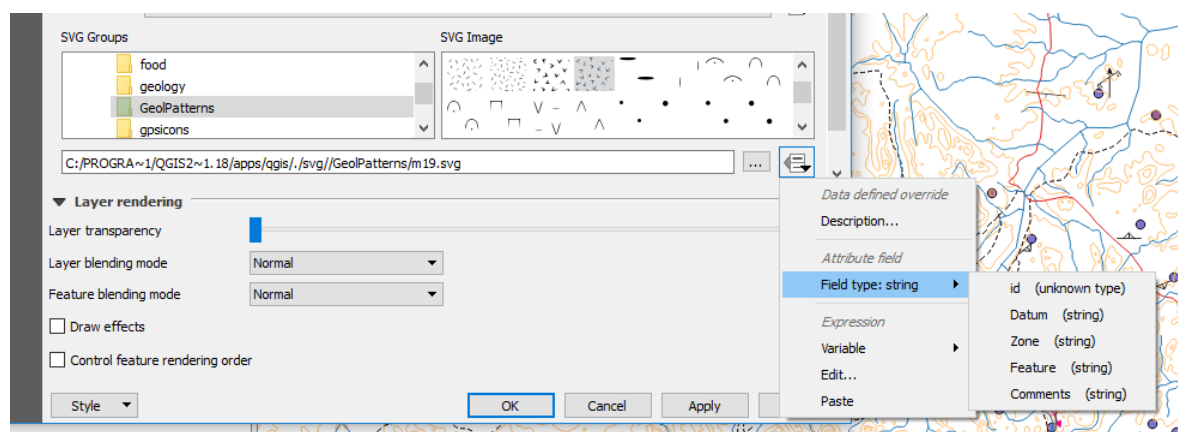
SVG files can be stored anywhere but the default location for the standalone install option is the Program folder, for example C:\Program Files\QGIS 3.6\apps\qgis\svg. Note that if you install QGIS via the OS4Geo option, the svg files will be located in the "C:\OSGeo4W64\apps\qgis\svg" for the long term 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 and additional svg directory location. If you upgrade your version of QGIS, you may need to copy your extra svg files back into this folder.

The image below shows the result of "Categorising" the geology and colouring each geological code type.

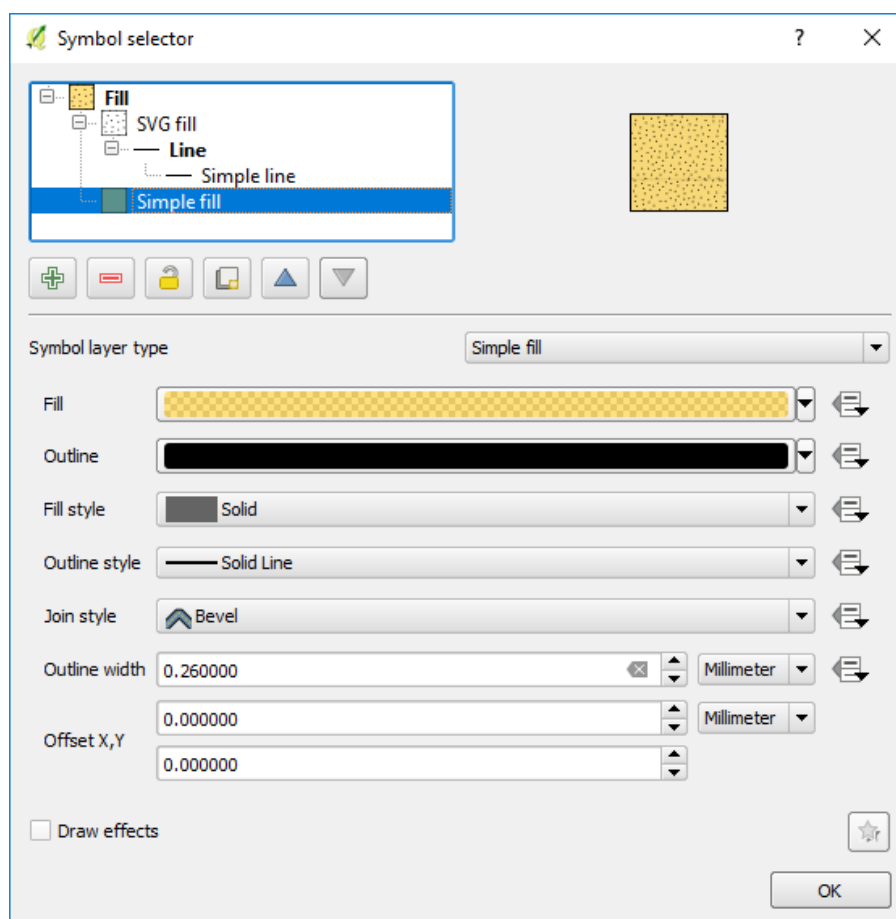




Note that you have options for size and rotation of the patterns or symbols. The SVG symbols and patterns have discrete file names which can be used to automatically assign symbols and patterns in the “Data Driven Override” of the layer properties file window.

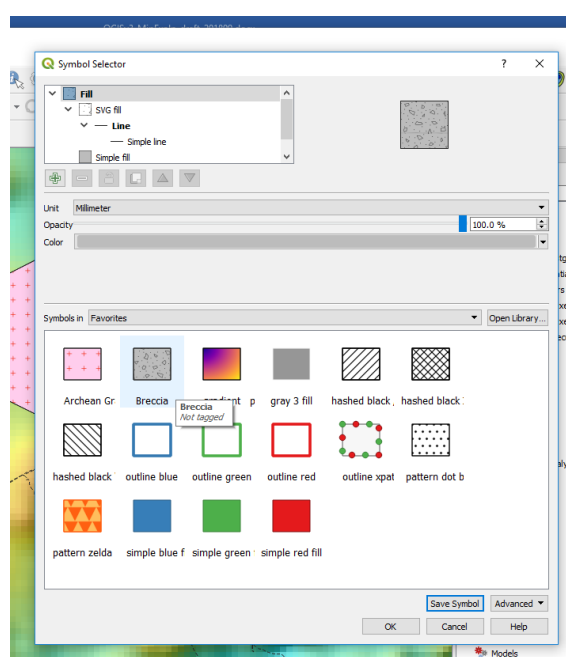


Coloured backgrounds can be added to the polygon fill by adding another layer in the Symbol Selector dialog box. Add a new symbol layer by using the green plus symbol, and move it to the bottom using the down arrow key below the display box.



For assistance in selecting colours, go to the “Color Brewer” web site (<http://colorbrewer2.org>) where there is a vast array of colours and their specifications available. Colour specifications can be specified in QGIS via their hex, RGB or CYMK number.

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



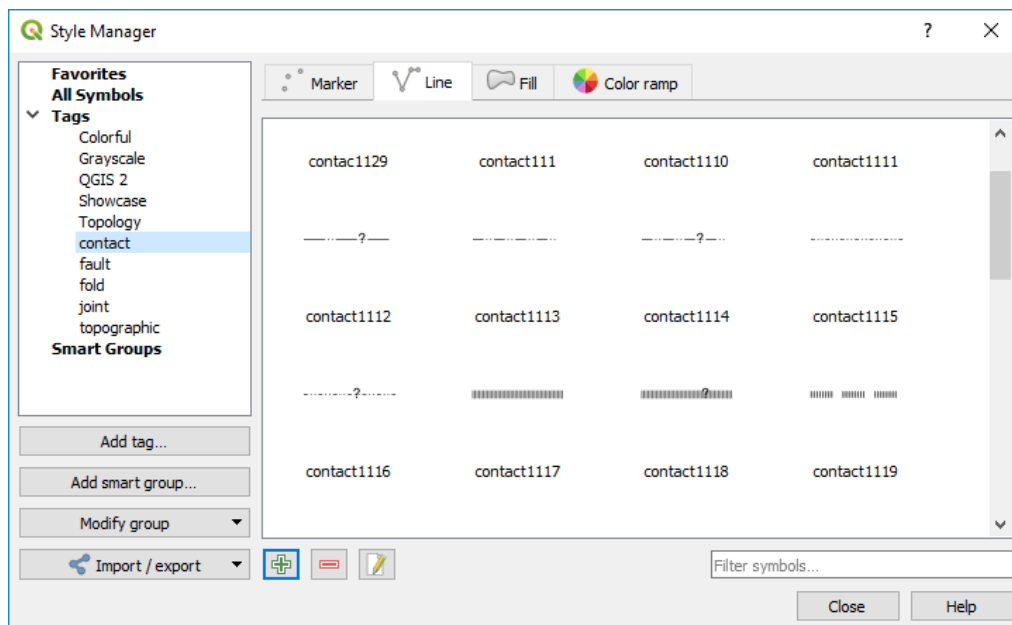


7.7 Geological Line Styles

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 https://ngmdb.usgs.gov/fgdc_gds/geolsymstd/fgdc-geolsym-all.pdf.

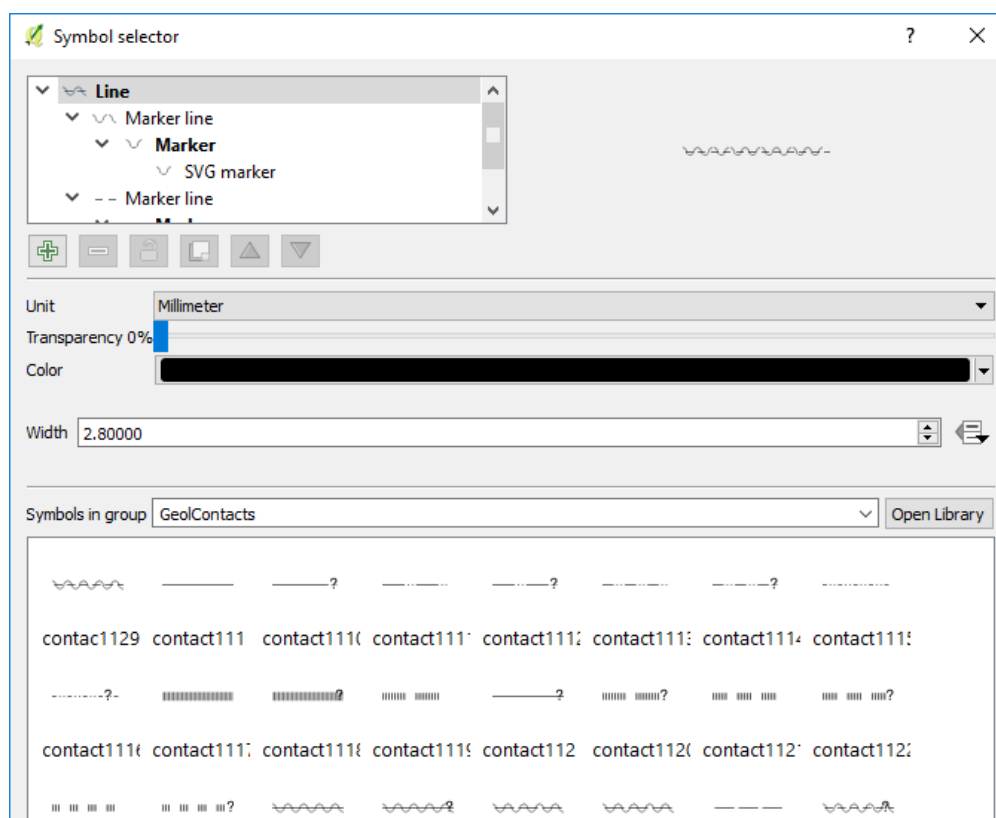
Style (*.xml) and symbol (svg) files can be found here at Stefan Revett's site <https://sourceforge.net/projects/qgisgeologysymbology/files/>.

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 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).

In the Symbols in group drop-down box, select GeolContacts (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).



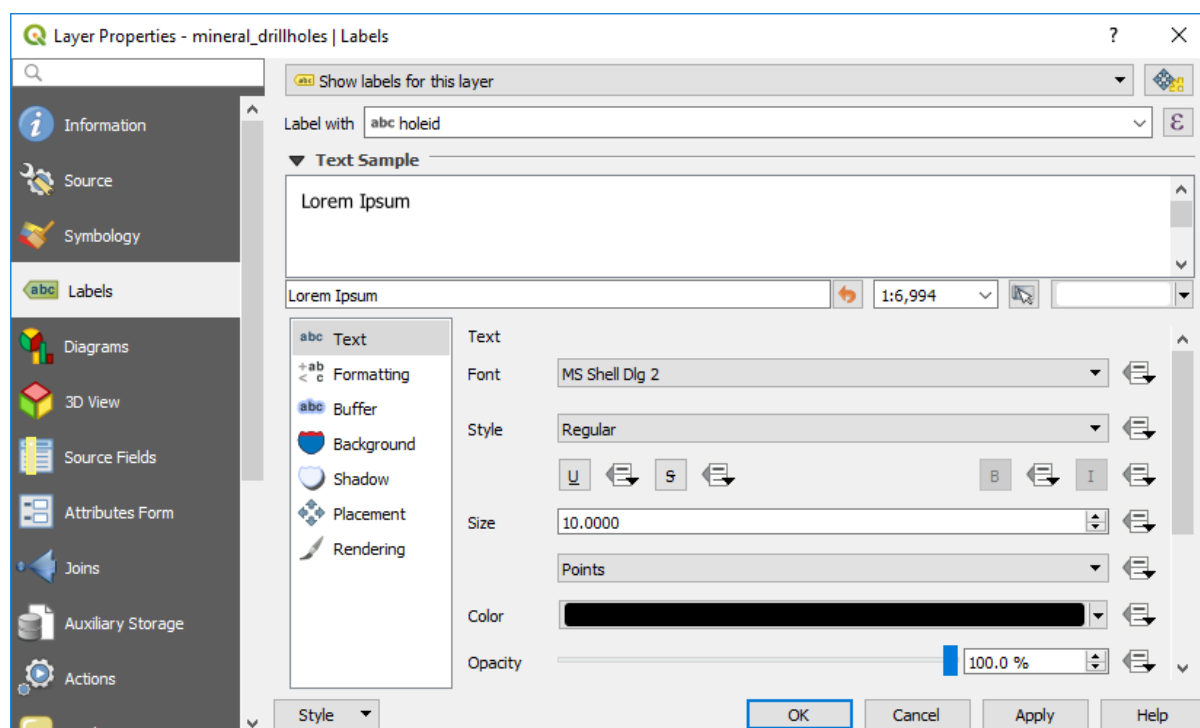
Any of these line styles can be edited manually by selecting the layer in the top window. Note that you change the line direction, e.g. fault ticks on other side, by using the “Reverse Line Direction” in the “Advanced Digitising Toolbar”.

7.8 Labelling Features

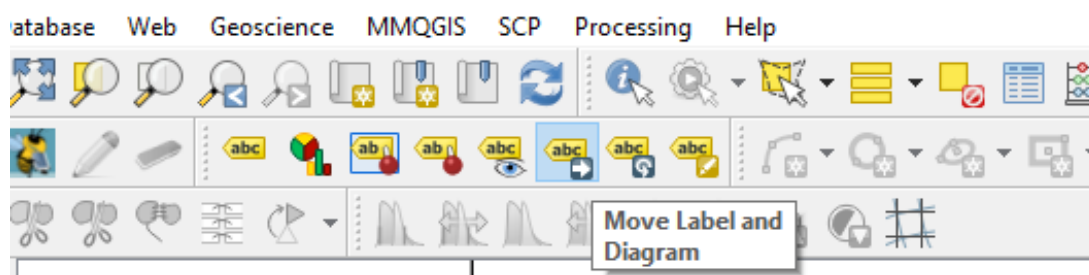
Features can be labelled via the Labels tab in the Layer Properties window for each layer. There are many ways to place labels and format them. I will give some examples typically used in geological applications below but there are many other options which you are encouraged to explore (see QGIS User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

Labelling points

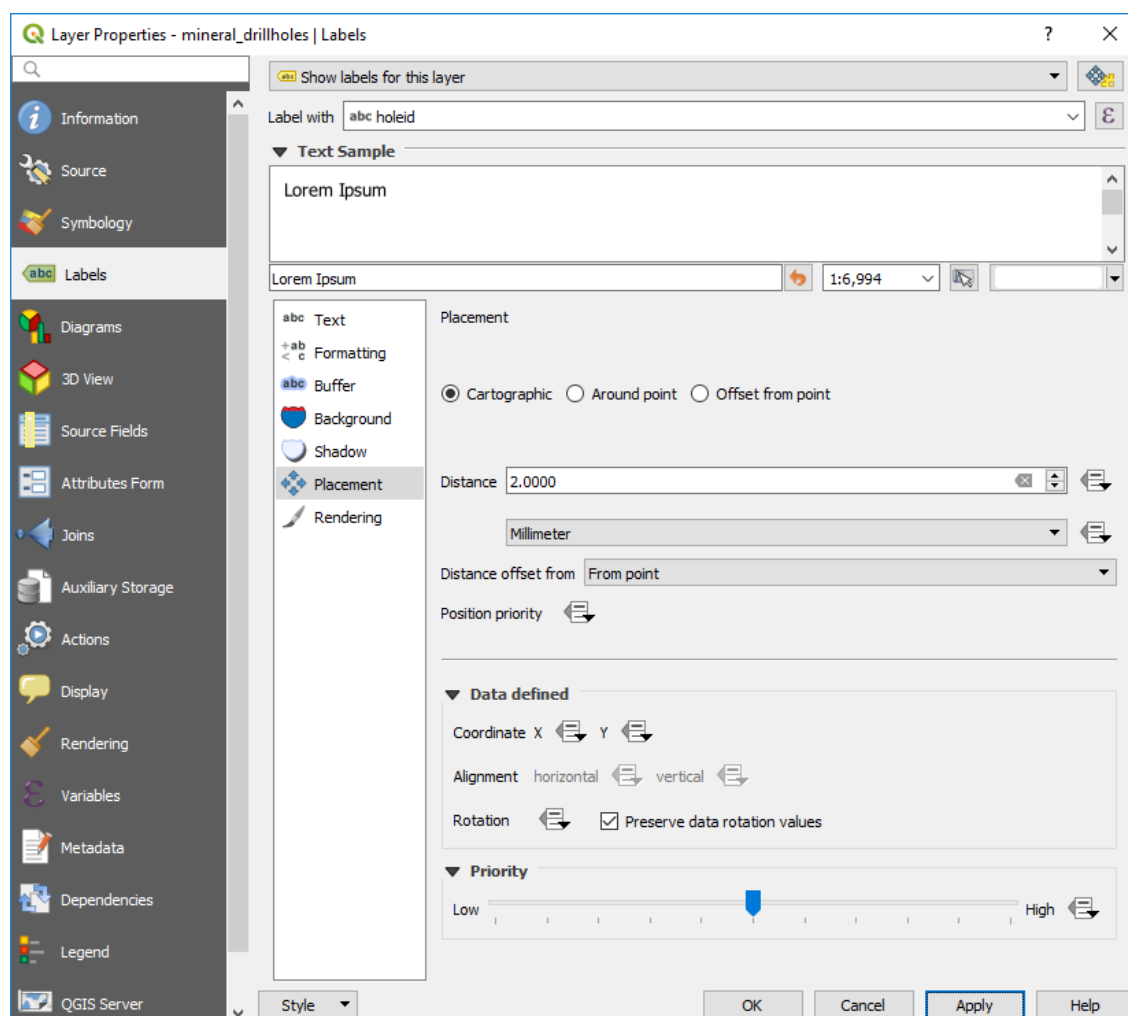
The Labels tab shows a variety of labelling options such as font type and size, whether you want a halo around the label (buffer) which is useful when the labels are over a coloured background. The Formatting section allows you to specify multi-line labels and word wrap options. The Placement options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



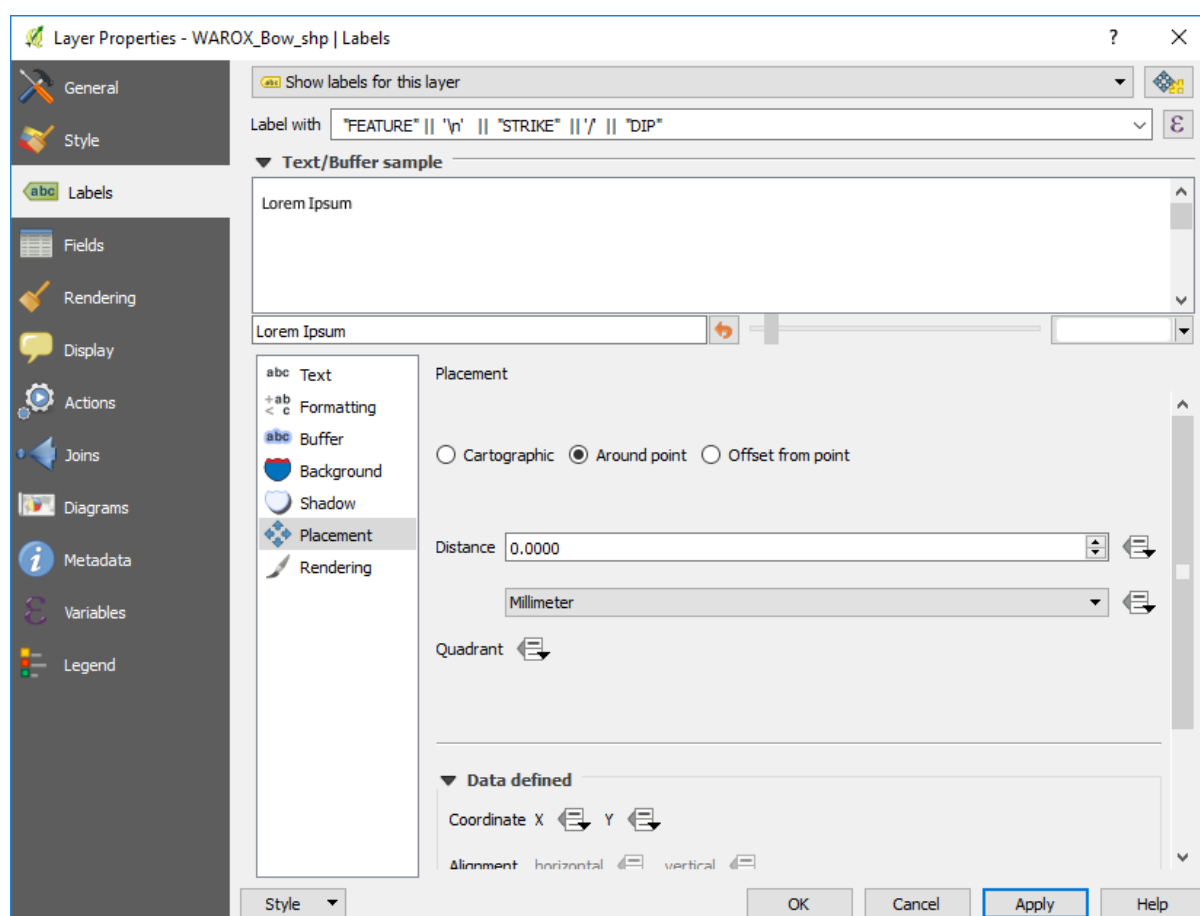
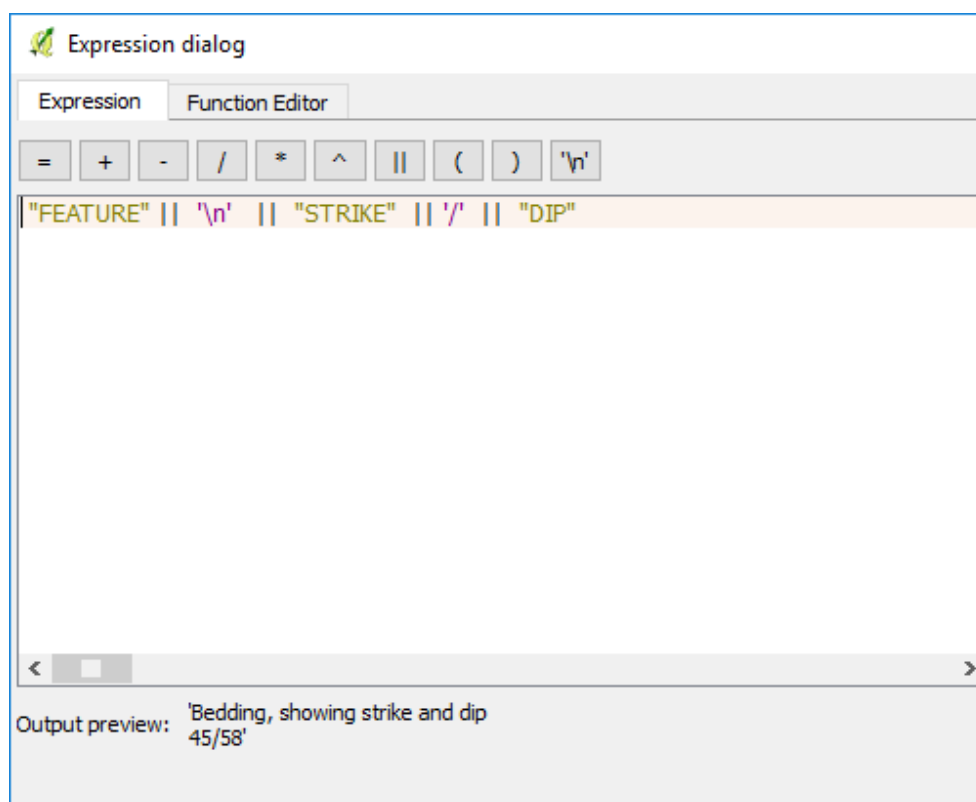
Note that to manually move individual labels, use the “Move Label or Diagram” option in the labelling toolbar.



There are three placement options and it is suggested to test these options for each particular 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.

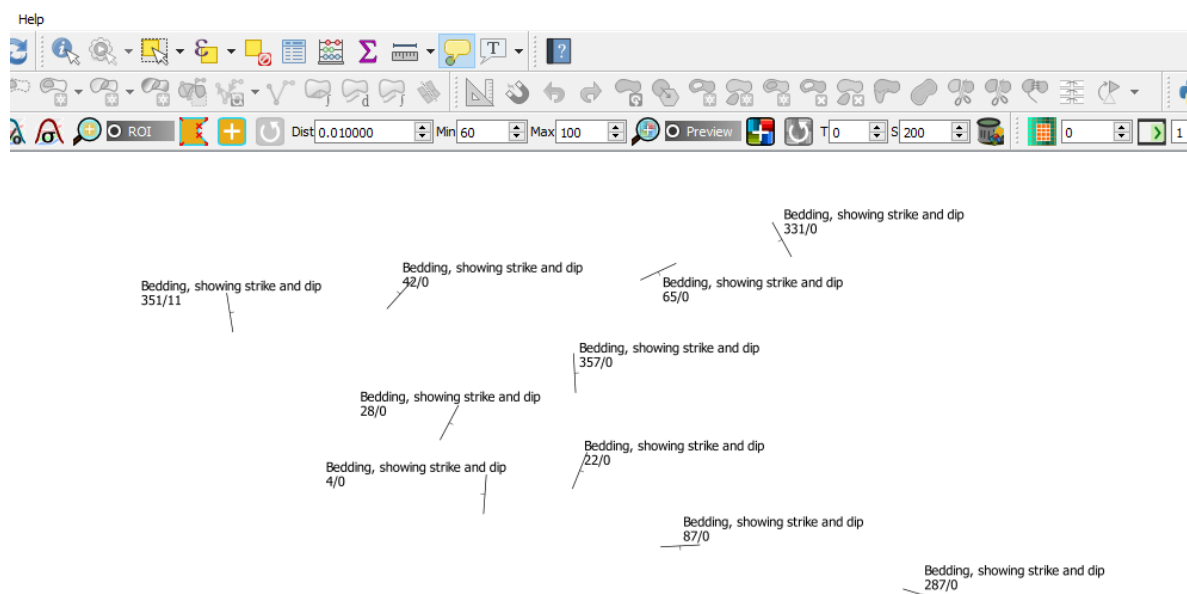


Multi-attribute labels can be created using the expression editor. Note the “Output Preview” in the lower left of the dialog box which shows how the labelling will appear.





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

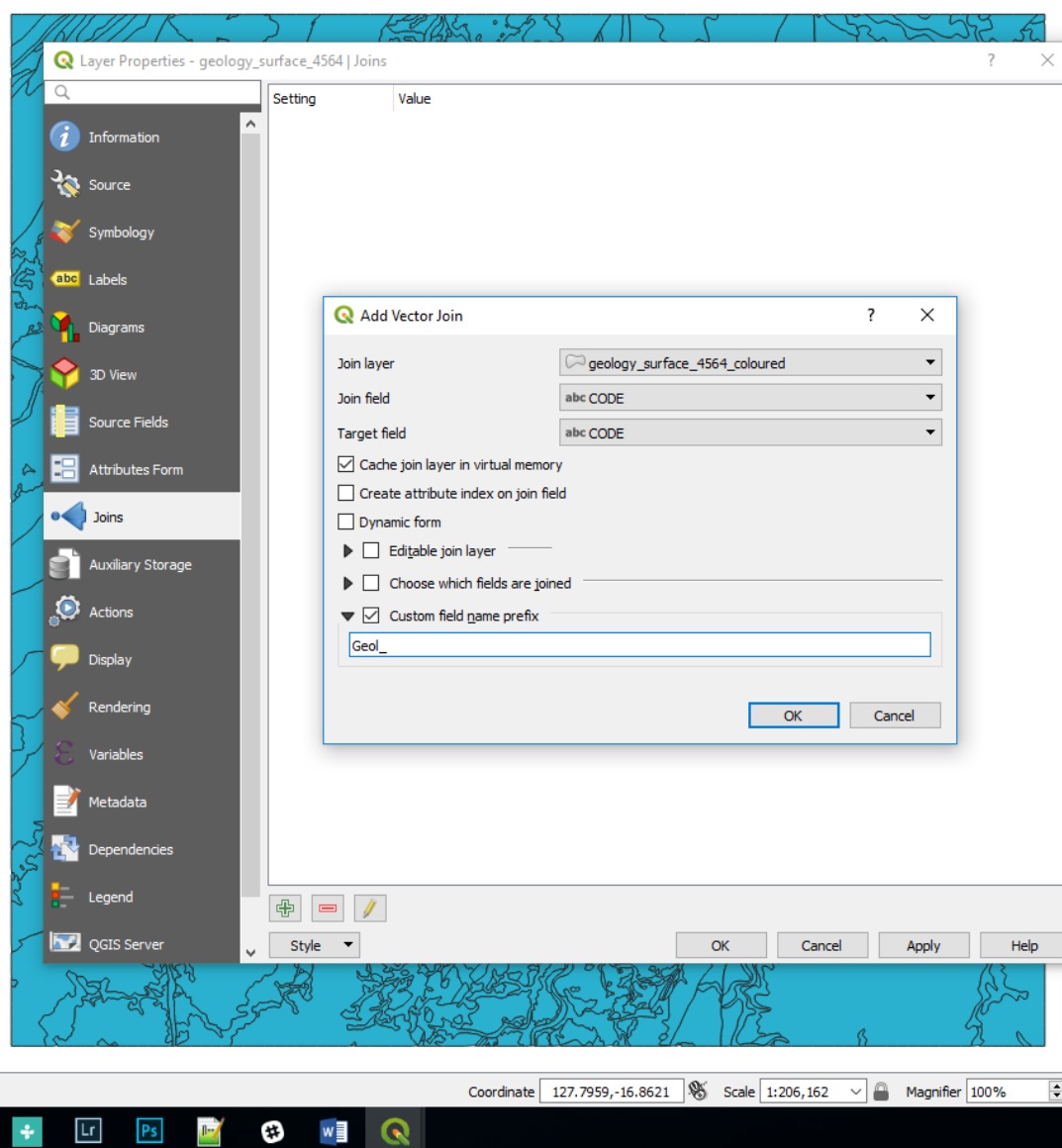


7.9 Joining Spatial and Non-Spatial Data

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 data). 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, 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 shape files 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.



geology_surface_4564 :: Features Total: 1041, Filtered: 1041, Selected: 0

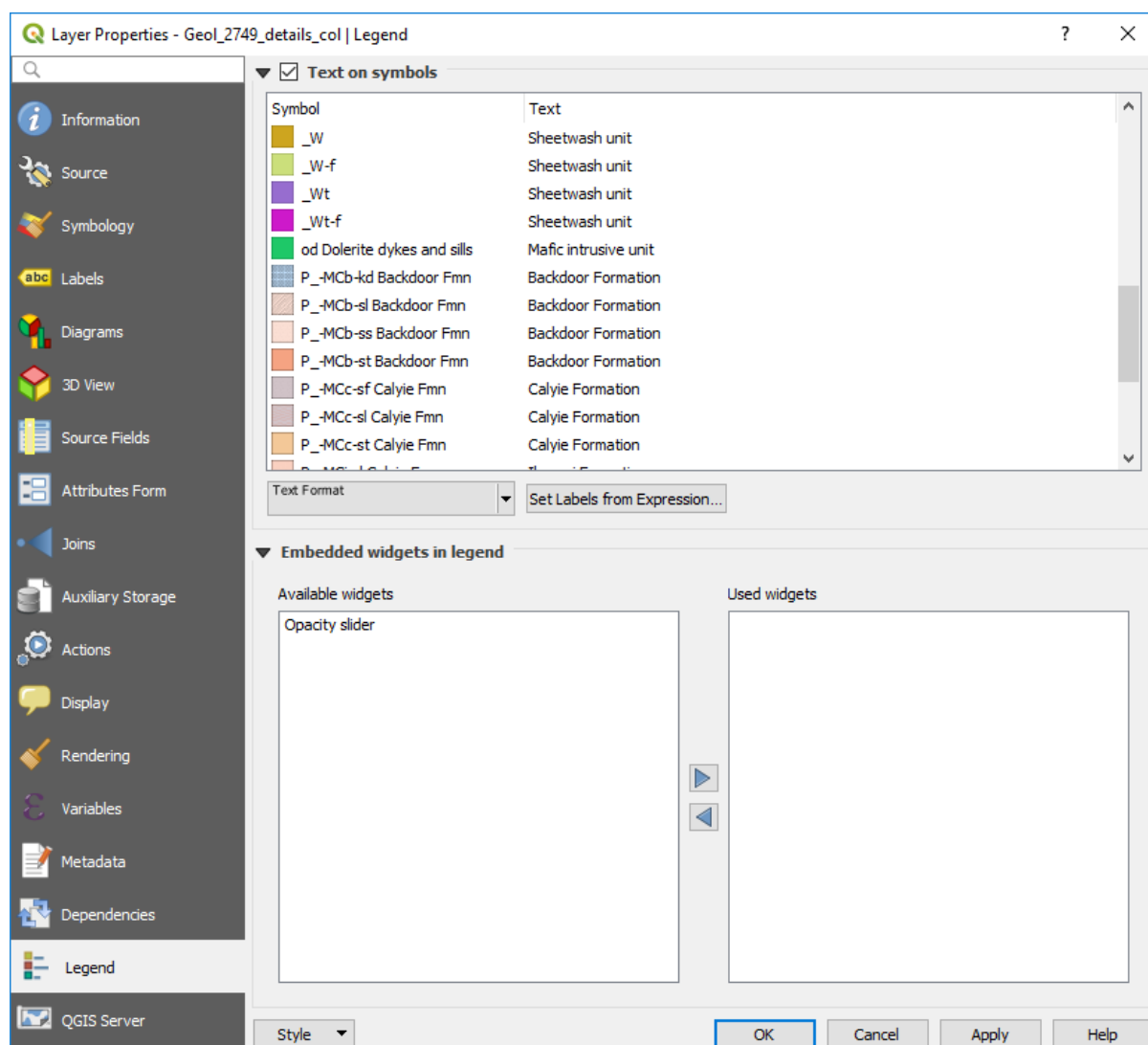
	AREA	PERIMETER	GEOOBS_	GEOOBS_ID	CODE	JNCODE	Geol_JNCODE	Geol_NARRATIVE	Geol_COMPI
1	0.00002	0.01937	2	108	Czsa	4564;Czsa	4564;Czsa	Alluvium and colluvium - partly con...	
2	0.00026	0.08337	3	107	PLGPe	4564;PLGPe	4564;PLGPe	biotite monzogranite	Lamboo Comp
3	0.00001	0.01472	4	106	PLCI	4564;PLCI	4564;PLCI	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	Czsa	4564;Czsa	4564;Czsa	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	Czsa	4564;Czsa	4564;Czsa	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...	

Show All Features

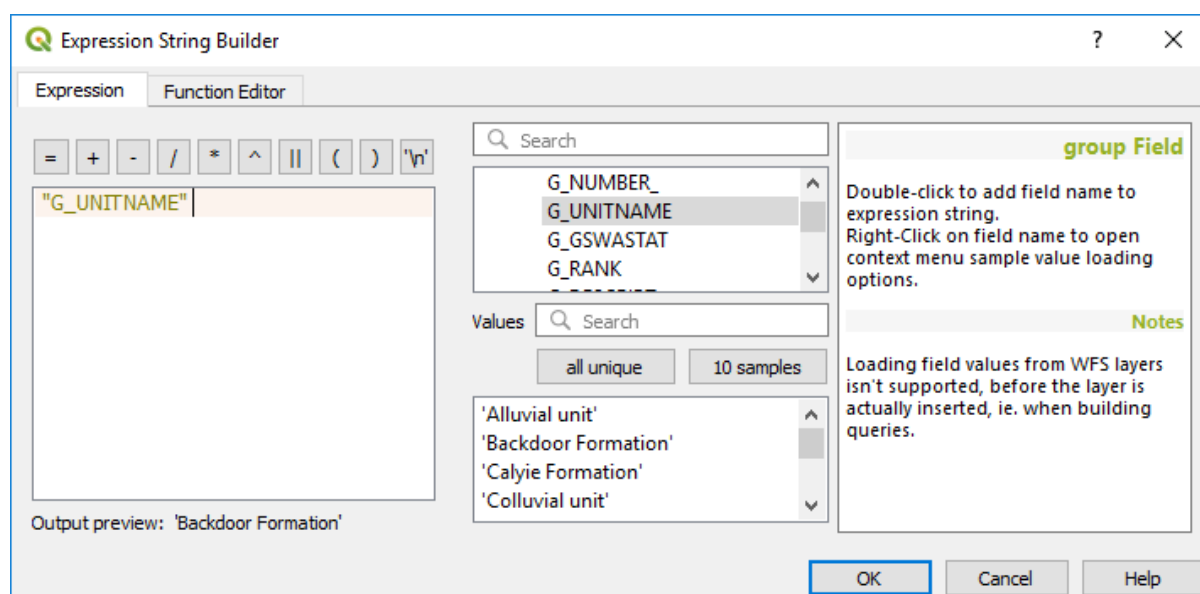
To make this a permanent join, use the “Save As” option by right-clicking on the layer name in the layers panel, and saving the file as a new shapefile layer. If you do not save this joined layer, the join will not be permanent, as it is a virtual join only.

7.10 Geological Legends

The creation of automated geological legends in QGIS has been updated. 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.

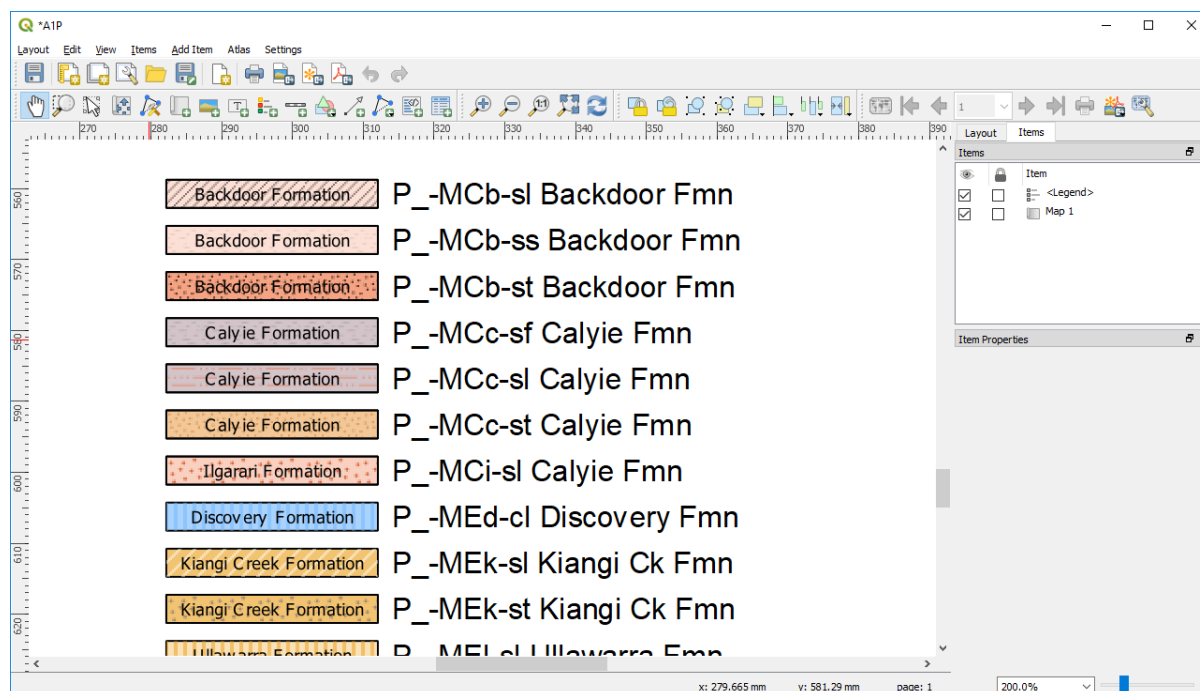


In the window above, the label text has been selected using the “Set Labels from Expression” which then opens the expression builder window (below).





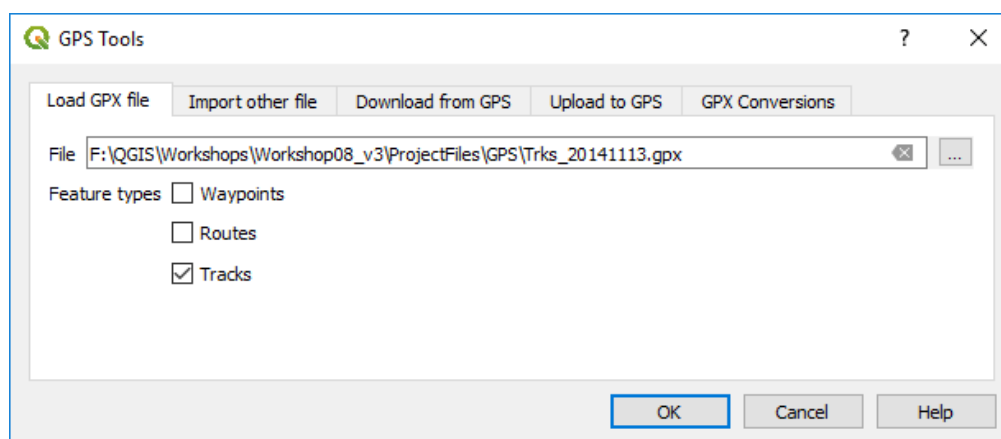
The legend will be displayed in the print layout window as shown below.



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.

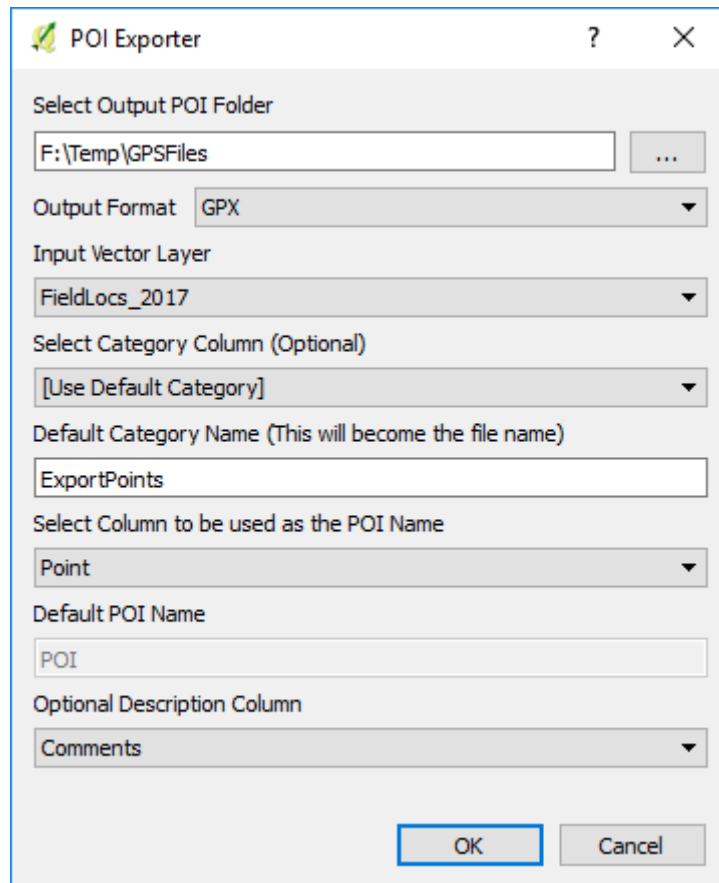
7.11 Importing and Exporting GPS Data

To import points and tracks from a gpx file collected using a GPS unit, use the menu item Vector > GPS > GPS Tools, 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. If this option is not available in your Vector tools, turn it on in the Plugin Manager.



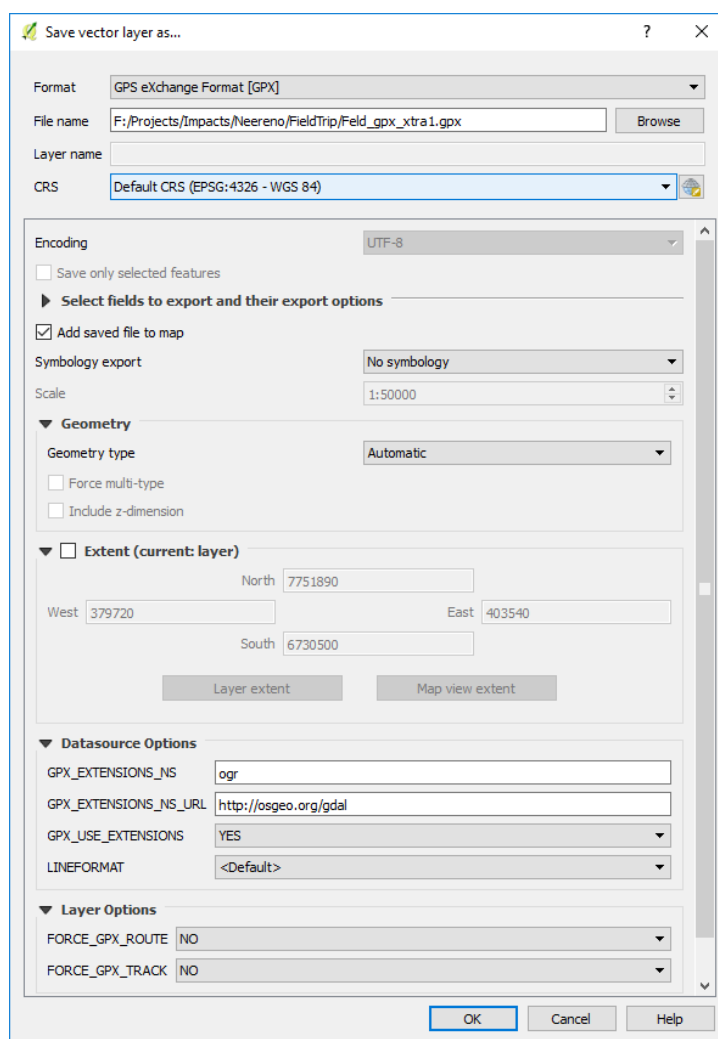


To send data to your GPS device, use the POI (“point of interest”) plug-in. The plug-in allows you to select the layer you want to upload, the column containing the point names (or ids) and an optional comments column (up to 254 characters). The plug-in creates a gpx file which can then be easily uploaded to your gps via a direct file transfer or GPSTabel (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.

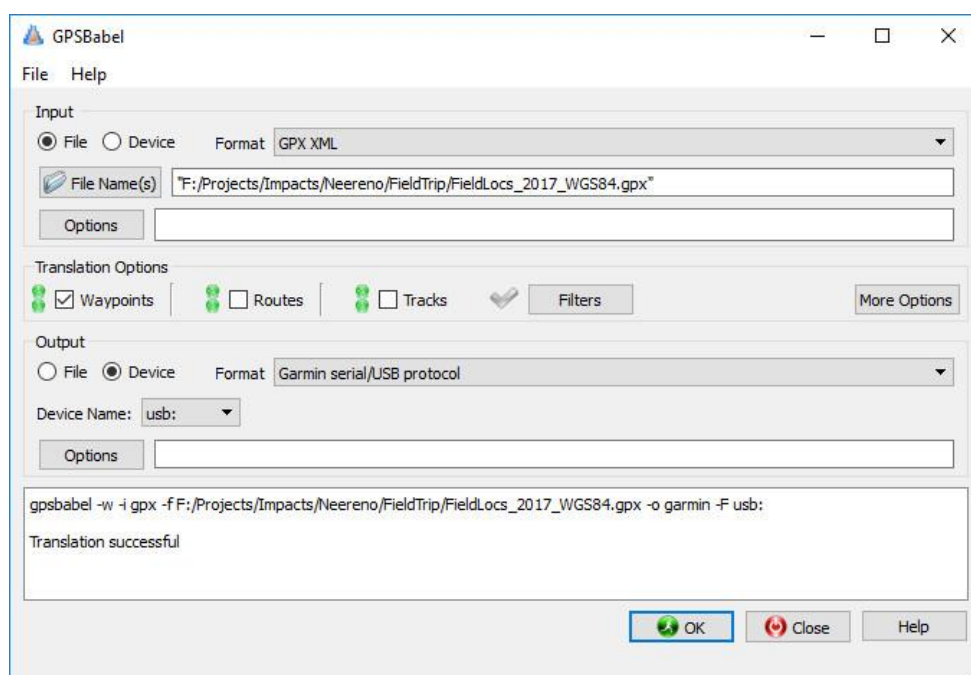


If you have problems with the gpx files, you may have to download the free “GPSTabel” utility (<https://www.gpsbabel.org/>) or purchase the GPS Utilities program (<http://www.gpsu.co.uk/>, US\$60). The GPS Utilities program has a vast array for GPS formats that you can read or write. After you imported the GPX file into QGIS, remember to save the GPS layer as a shp file to allow for editing of the data.

Note that 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”. Note that 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. Note that 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. 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 shape files 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 GPSTabel 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 database contains the GSWA field locations, sample sites, outcrop photos and petrography reports. The Microsoft Access database supplied by the GSWA contains a number of queries to make it easier to access the data. The query “qry_photos_Locations” allows the user to extract the sites where photographs have been taken of outcrops. To import this data into QGIS, export the query as a csv (qry_photos_Locations.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.

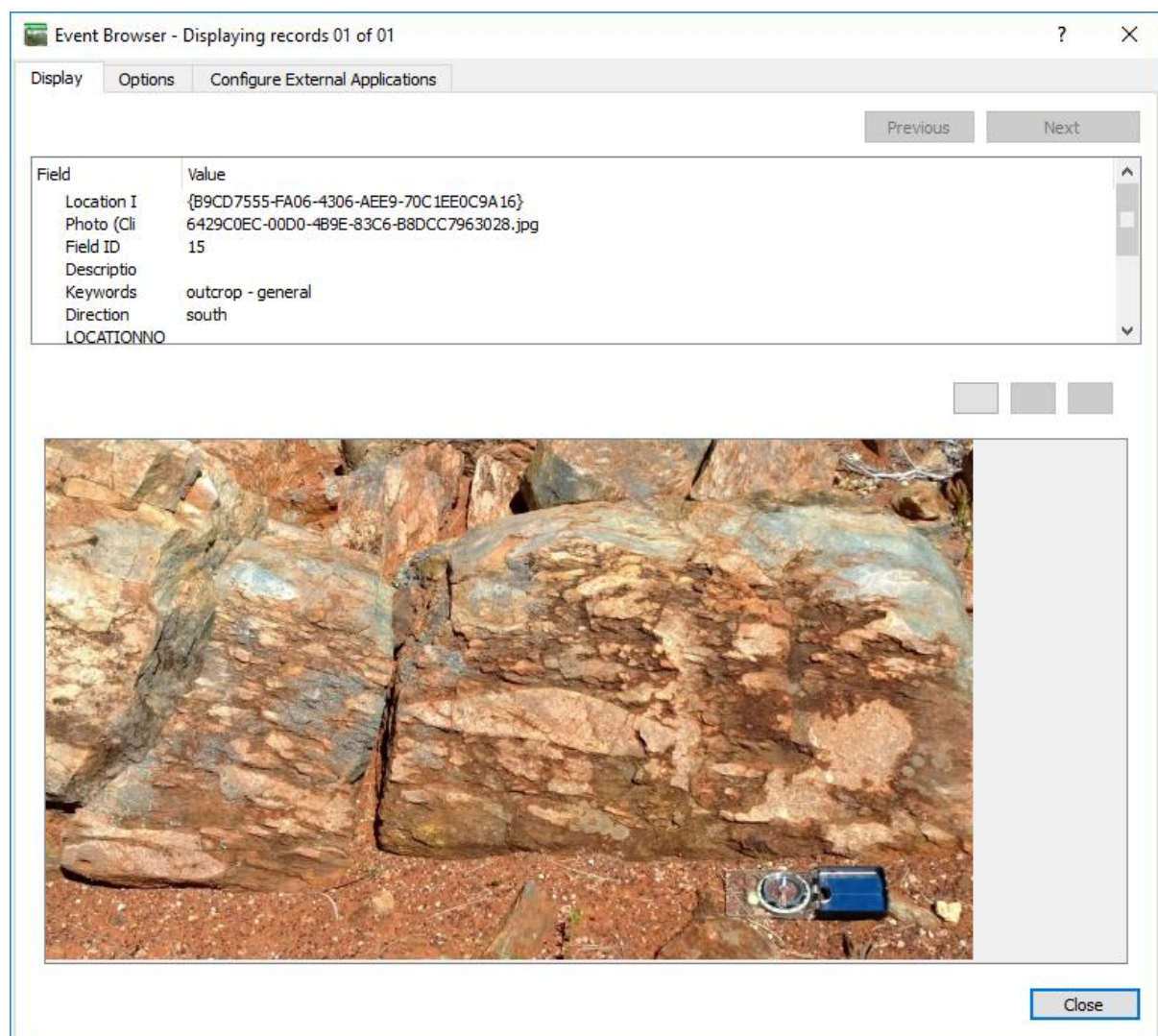
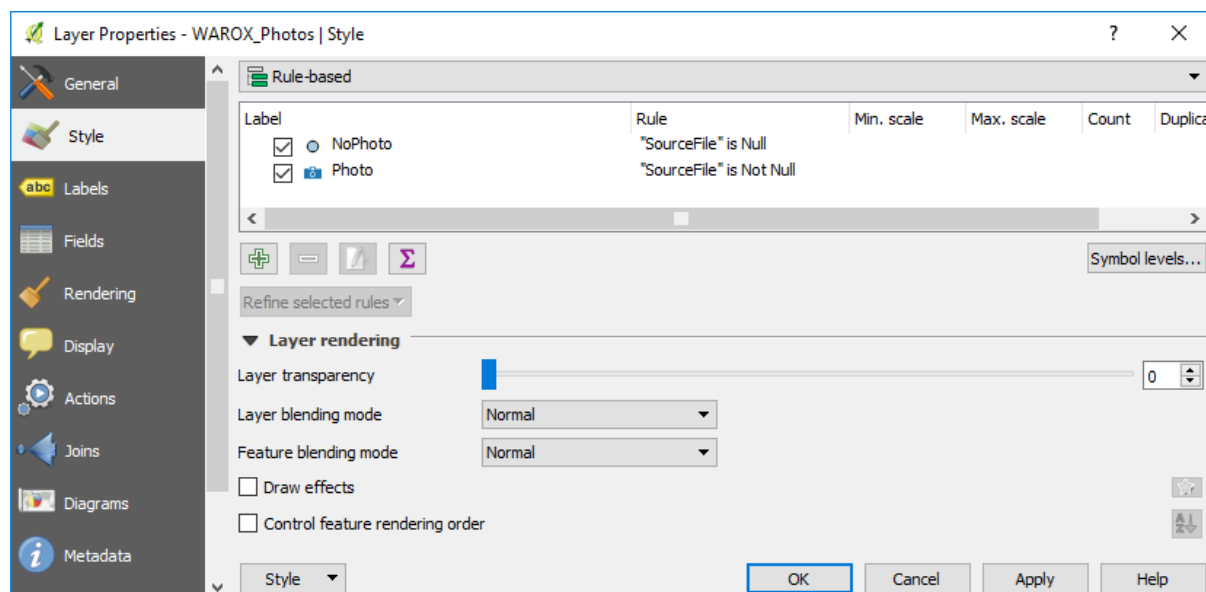
In QGIS, open the layers attribute table, make editable and add another column (called something like “SourceFile”) of type string (text) with width of 100 characters. Save this update. This “SourceFile” column will hold the file location and photo number that will allow QGIS to display the photo for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

	LOCATIONNO	SITEID	DLAT	DLONG	SourceFile
1	455490	RHSMUG001857	-25.9680700000...	127.8175499999...	F:/Projects/WA/WAROX/PHOTOS/WAROX/E741594B-F660-4E5C-8980-AAF6D5CDFB8C.jpg
2	533013	RHSMUG002498	-26.1122500000...	127.4201400000...	F:/Projects/WA/WAROX/PHOTOS/WAROX/48578BA4-4F3C-49A3-BC87-D3E8CC65ED5E.jpg
3	533013	RHSMUG002498	-26.1122500000...	127.4201400000...	F:/Projects/WA/WAROX/PHOTOS/WAROX/64E74152-6977-4EDB-8FA0-37A46DC8450B.jpg
4	505528	RHSMUG002283	-26.1214599999...	127.5252100000...	F:/Projects/WA/WAROX/PHOTOS/WAROX/30A6805E-43C8-4FAE-81FA-FA0F4B62363D.jpg
5	416288	PMEMUG000523	-25.6377600000...	128.1871399999...	F:/Projects/WA/WAROX/PHOTOS/WAROX/8EB85D81-1FCA-4486-8D1D-9FBF3686A6D6.jpg
6	416288	PMEMUG000523	-25.6377600000...	128.1871399999...	F:/Projects/WA/WAROX/PHOTOS/WAROX/91099019-1FDA-498F-8A0A-9008AF450764.jpg

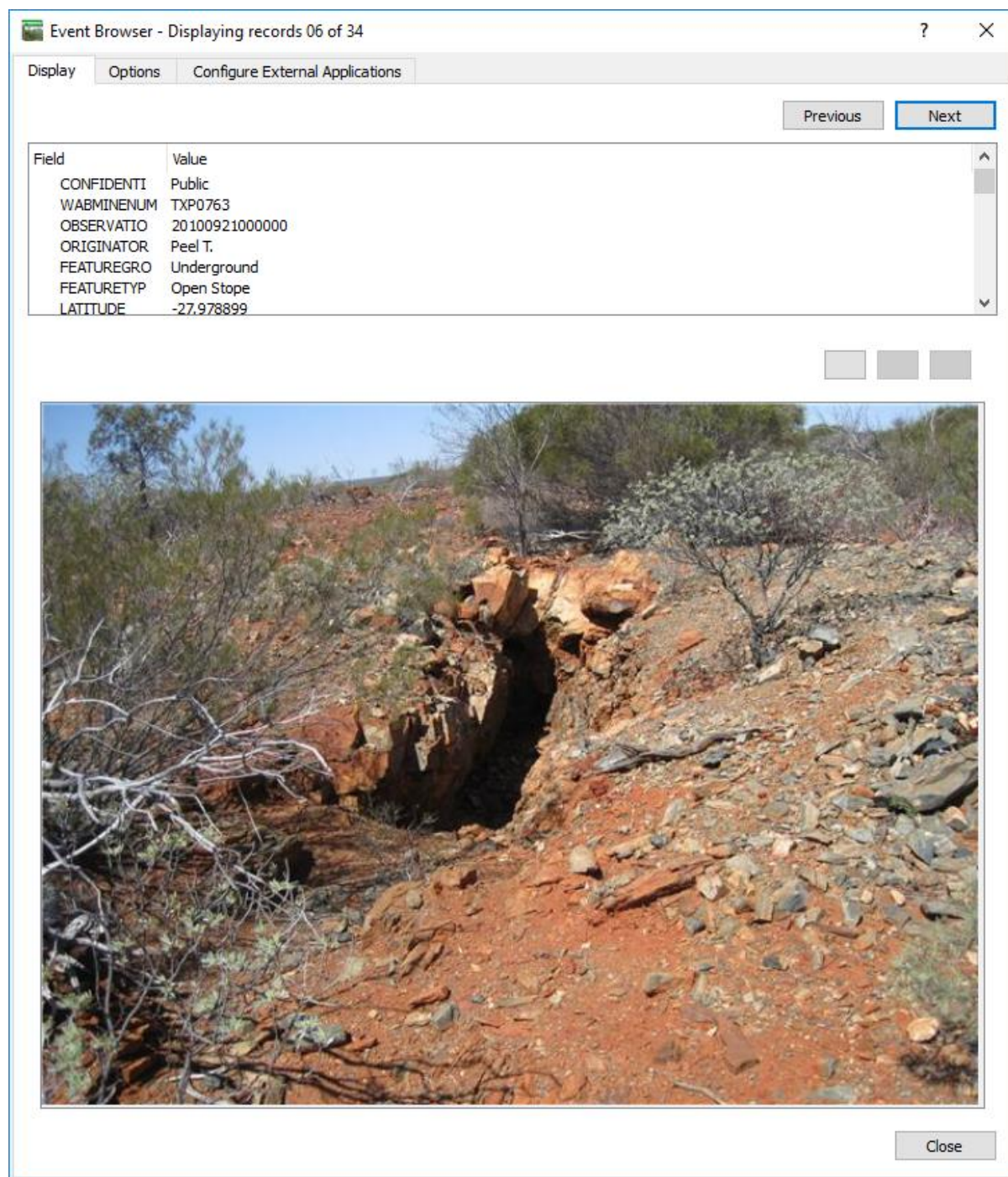
You may want to Categorise the points into those with and without photos using a “Rule based” styling using photo SourceFile is Not Null for points with photos (meaning there is a photo link), and no photo when SourceFile is Null (no photo link). I have used a photo icon to indicate if there is a photo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

After saving the file, you can then use the eVis plug-in (Database > eVis > EVis event id tool) to click on and display photos linked to that site. 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.





7.13 Converting Local (Non-Earth) Grids to Real World Coordinates

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 is usually 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 work flow below is for point data and within one UTM zone in metre coordinates only.

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.

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



8: DISPLAYING GEOCHEMICAL DATA

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.

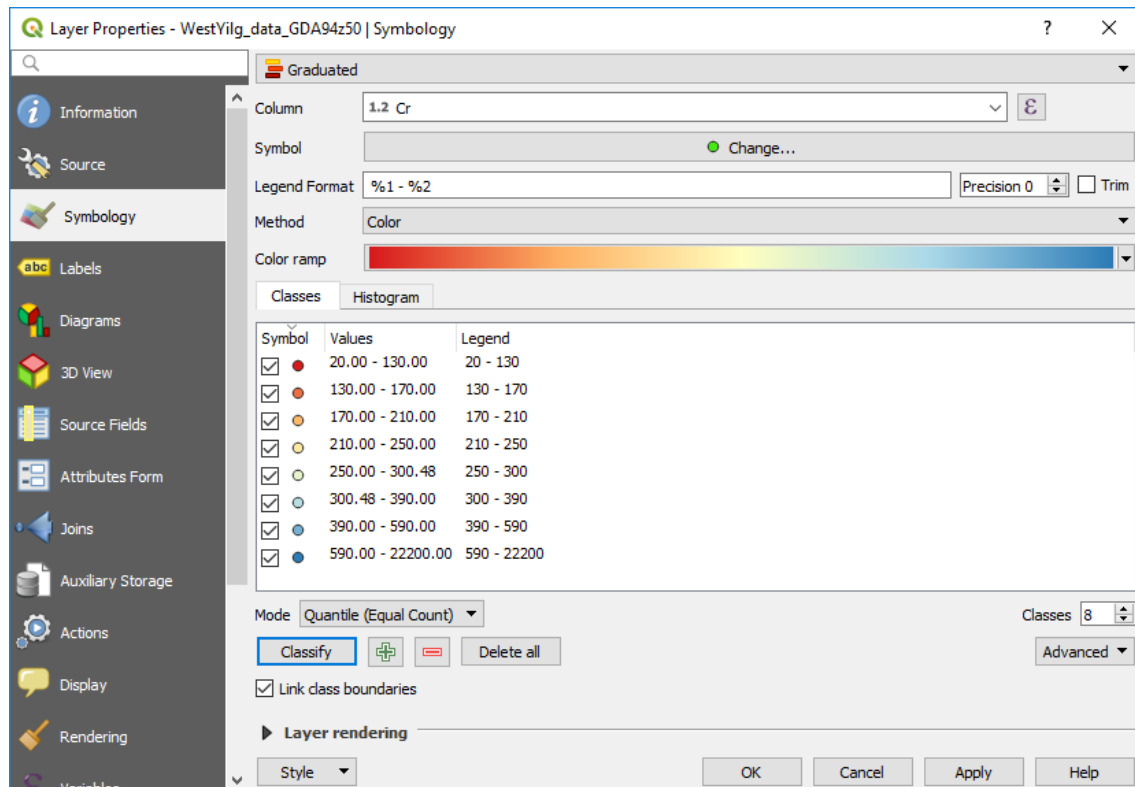
IOGAS has supplied a trial QGIS plugin for its export files and this is currently being tested. Hopefully it will be due for public release soon.

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 and the data is in the correct place. Google Earth, satellite imagery or open street map vector data can be used for this purpose. The simplest display is a series of points where the symbol can be displayed in different colours and sizes by sample value.

Geochemical point data can be displayed as points and can be coloured or sized according to value. 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.

If you select 8 classes and the “Quantile (Equal Count)” method this will calculate the 1st and 3rd quantiles as the second and seventh quantiles. For example, the displayed data set has a first quantile value of 10 and a third quantile value of 66. The Inter-Quantile Range (IQR) is therefore 56, and by calculation, the anomalous data threshold of “Cu_ppm” is $3^{\text{rd}} \text{ Q} + (1.5 * \text{IQR}) = 84$. These values can be checked by using the Statistics Panel.



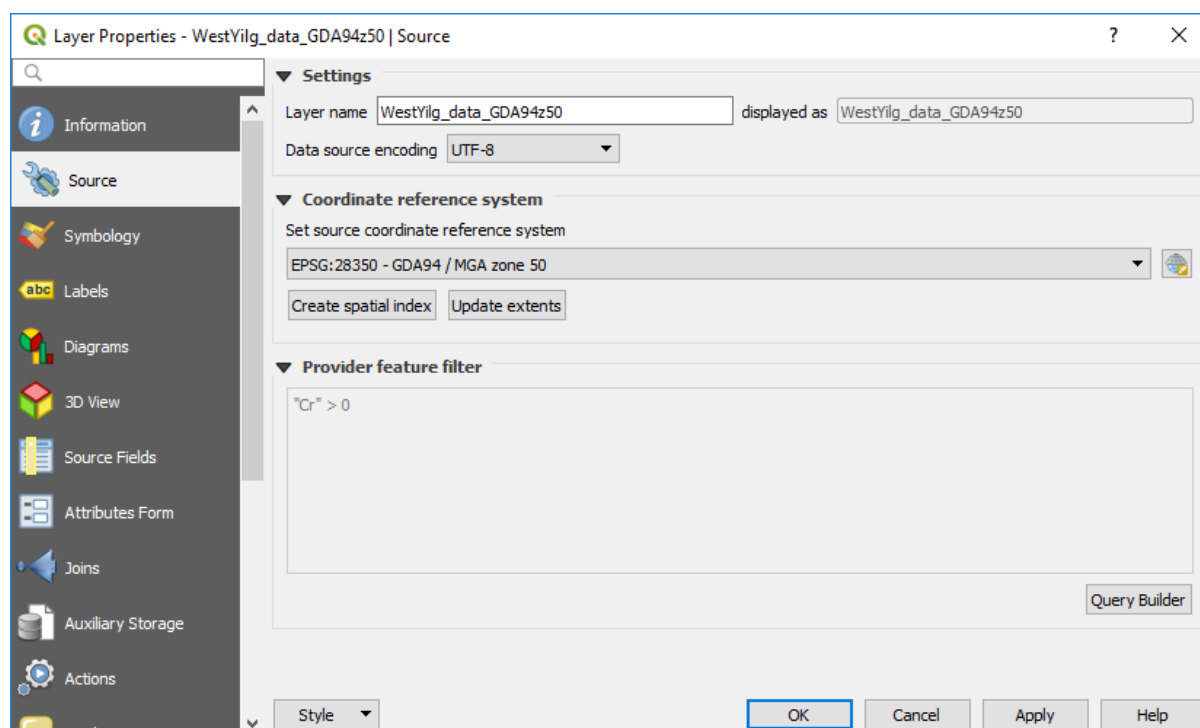
Statistics can be carried out on geochemical data in QGIS. Univariate statistics can be calculated using the View > Statistical Summary panel. This opens a panel under the browser panel, where you can select the layer and data field for which field you want to calculate statistics. The mean, standard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



Statistics	
WestYilg_data_GDA94z50	
1.2 Cr	Σ
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

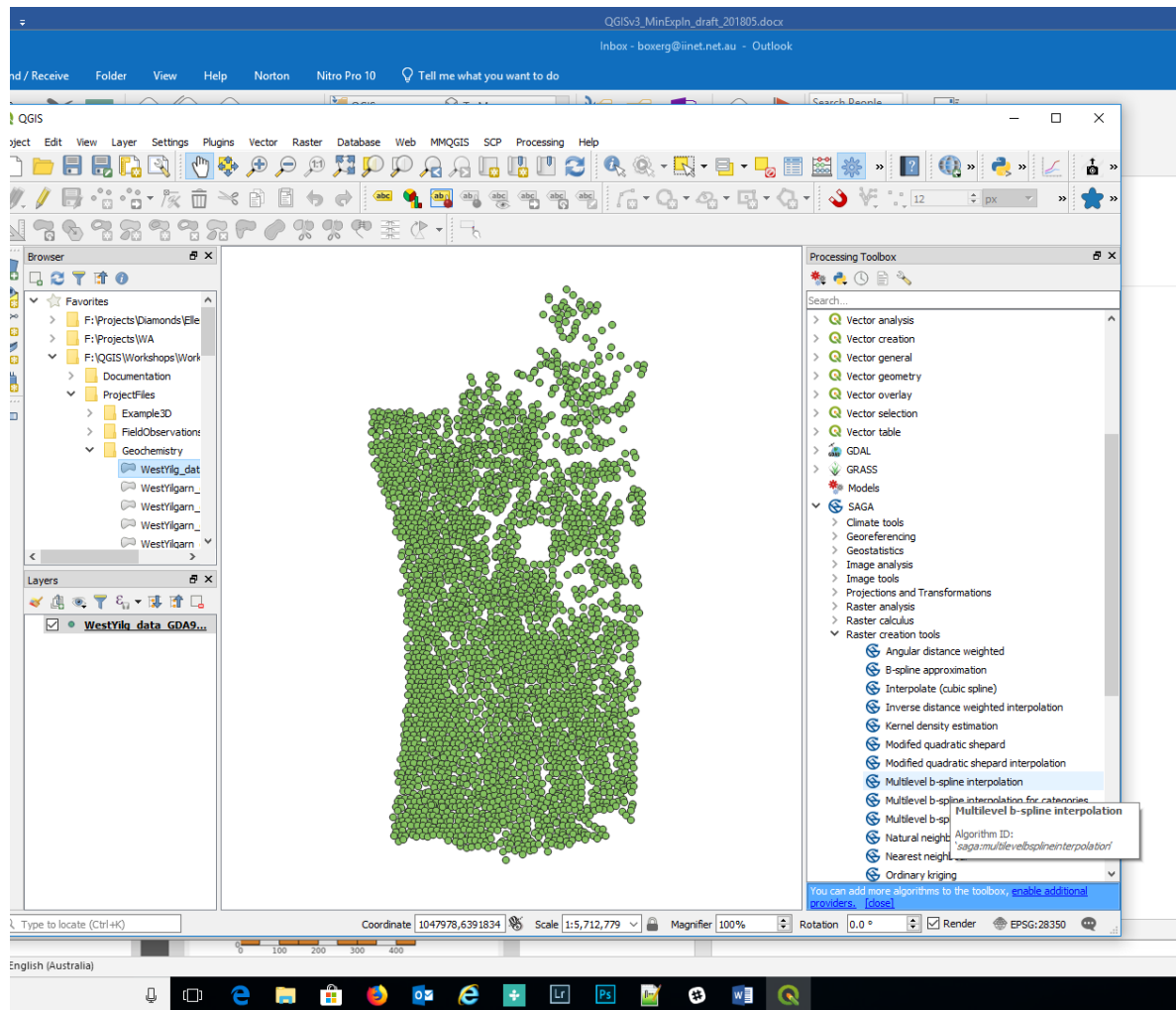
☐ Selected features only

Note that the user must ensure their data has been verified and checked, so as not to introduce anomalous results caused by below detection assay results, e.g. “-5” as a replacement for below detection at a 5 ppm detection limit. In this example of Cr data, I have filtered the data to only use data > 0 to avoid the below detection and not assayed (-999 type codes).

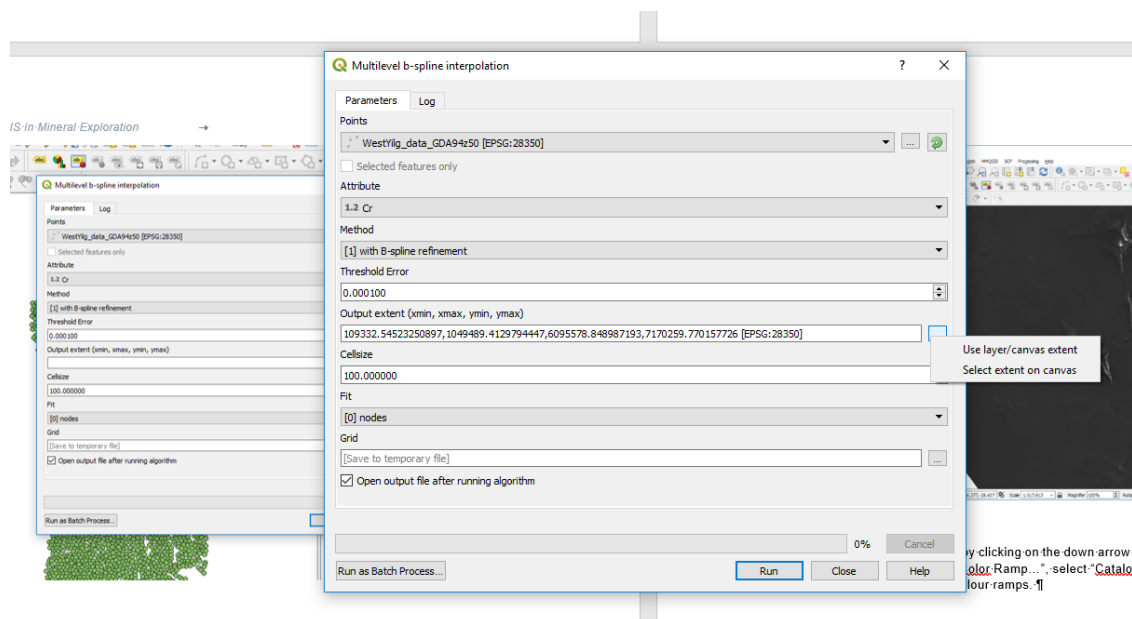


Geochemists traditionally use “box and whisker” plots to display the mean, median, first and third quantile, interquartile range (IQR) and anomaly threshold level (third quartile plus 1.5 times IQR). The IQR is the difference between the third and first quantiles.

Gridding of geochemical data is common where there are a large number of approximately regular located sample points. Gridding can be done via the Processing Toolbox > SAGA > Raster creation tools. A large number of gridding options are available and one I have used most often is the “Multilevel b-spline interpolation”. If the Processing Toolbox is not displayed, go to the top menu Processing > Toolbox.

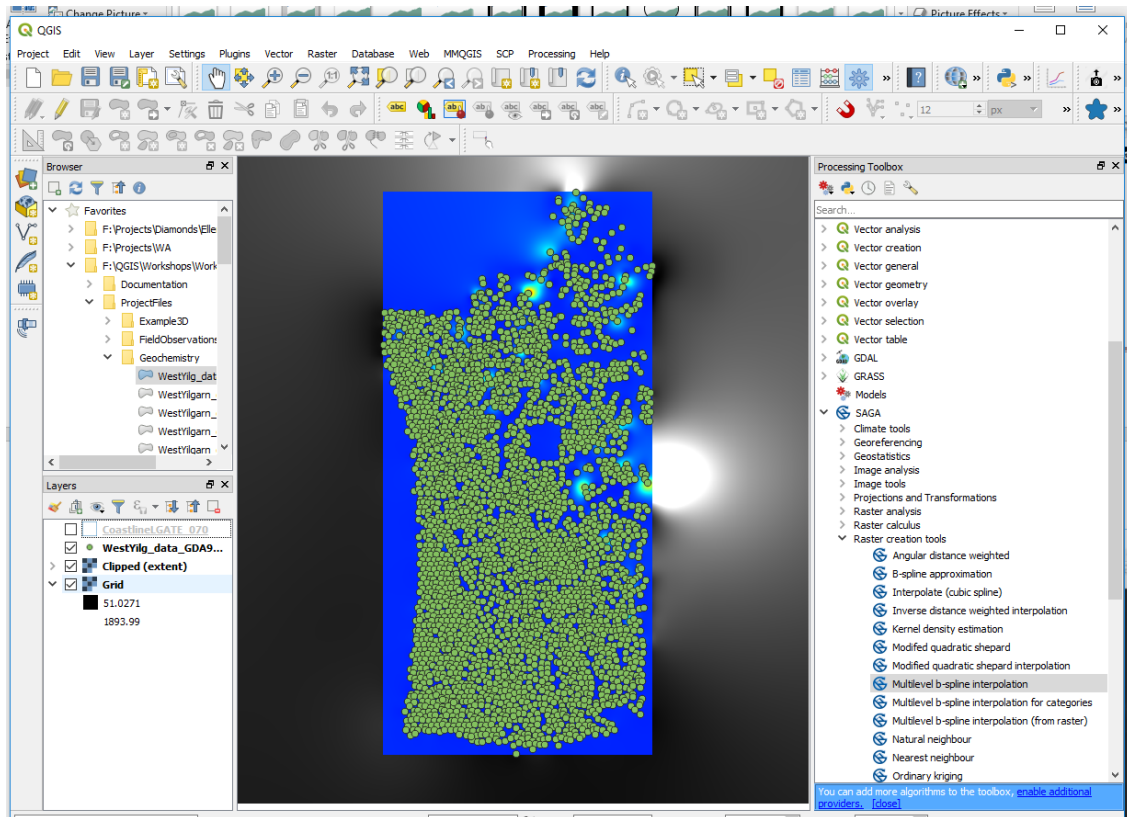


Each gridding method will have parameters specific to that method and the user will be required to know what effect each parameter will have on the resulting grid.

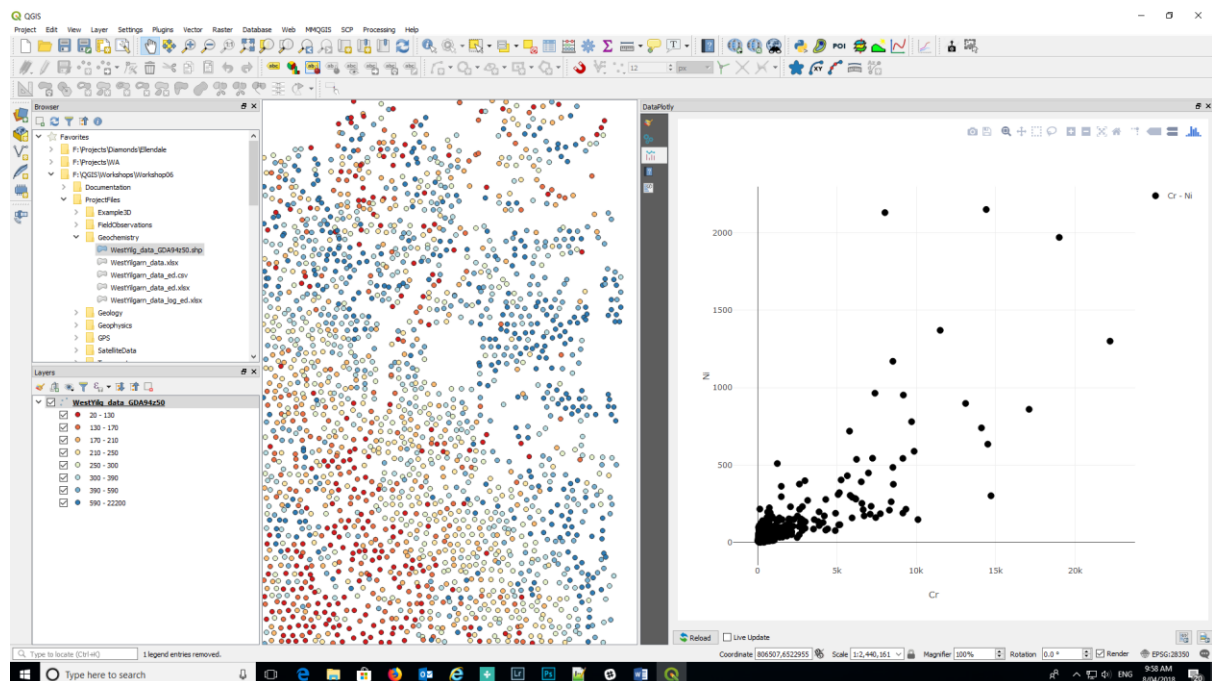
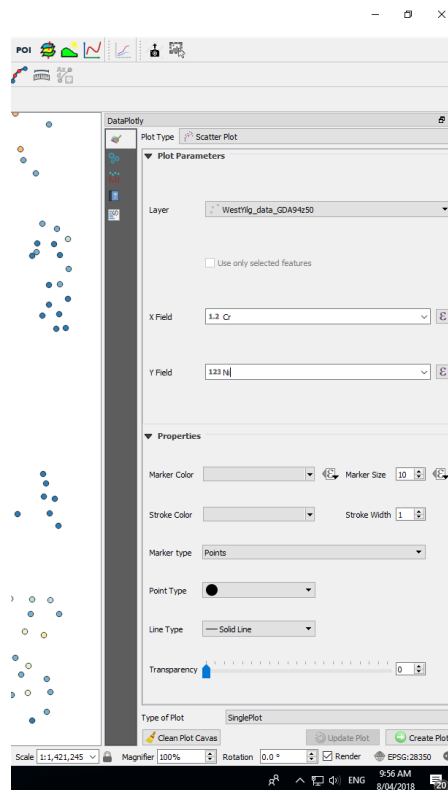




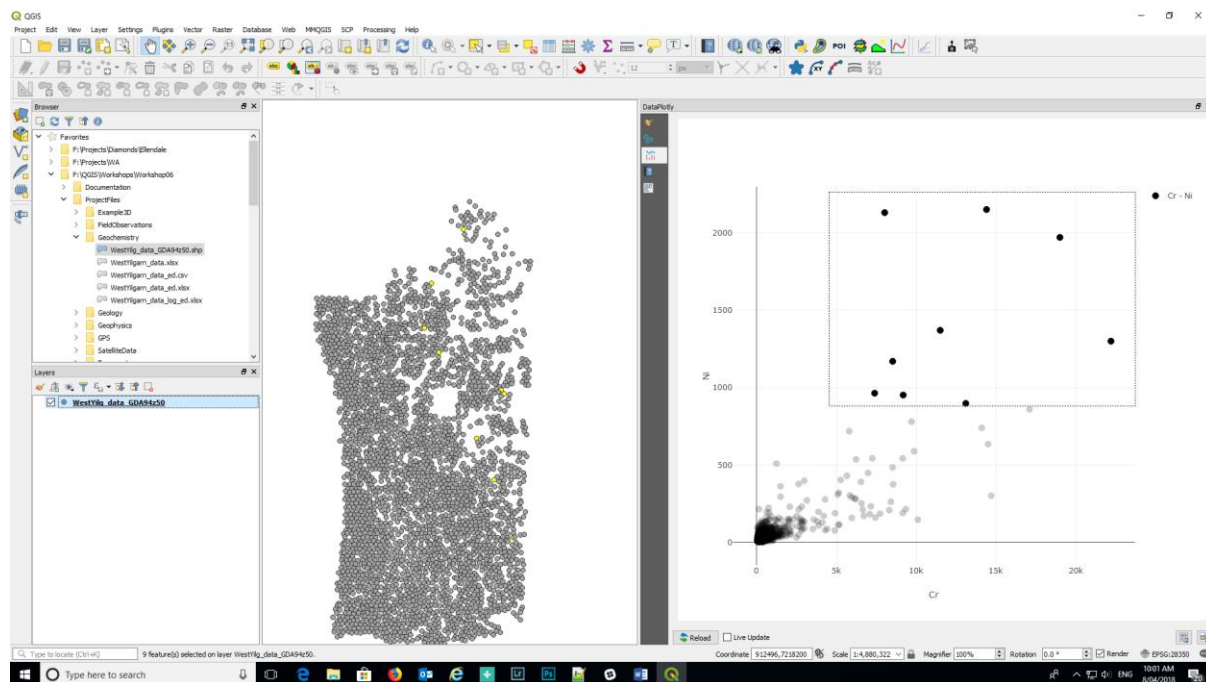
The created grid is not clipped to the data but this can be achieved via the Raster > Extraction > “Clip raster by mask layer” menu item. The image below shows the grid clipped to the data but a user created polygon mask would probably produce a better result.



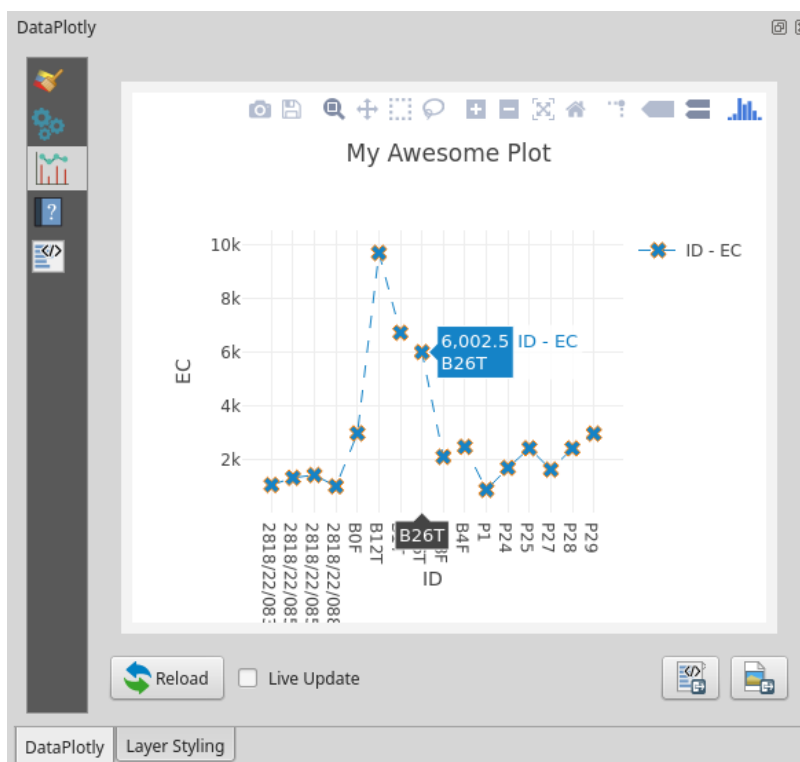
QGIS v3 allows for the plotting of data via the Data Plotly plugin. Various plotting options are available. The image below shows a simple scatter plot of Cr vs Ni.



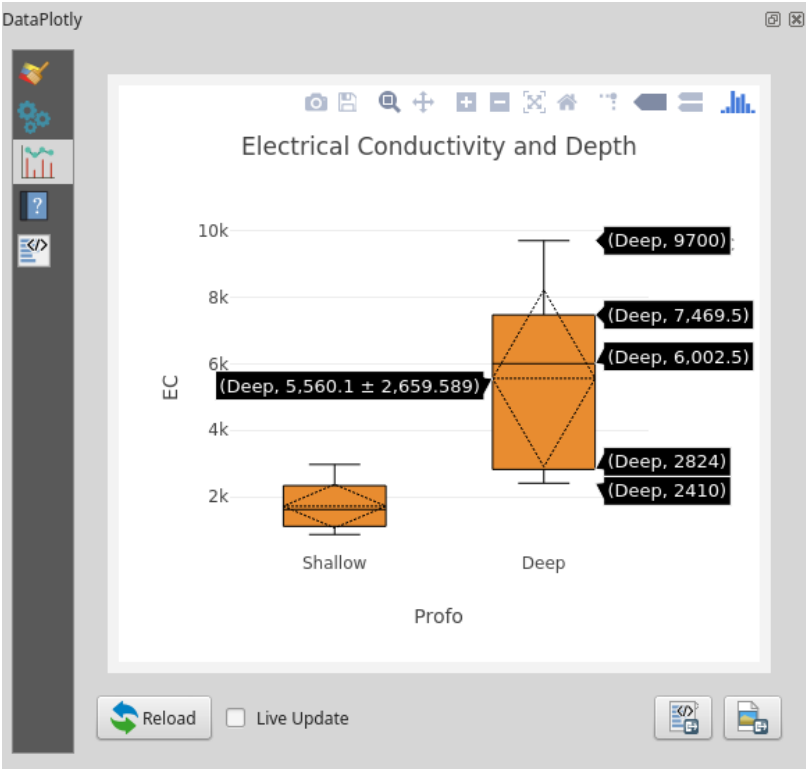
Data points selected on the plot can be highlighted on the map.



Other example plots are shown below are from the DataPlotly site.



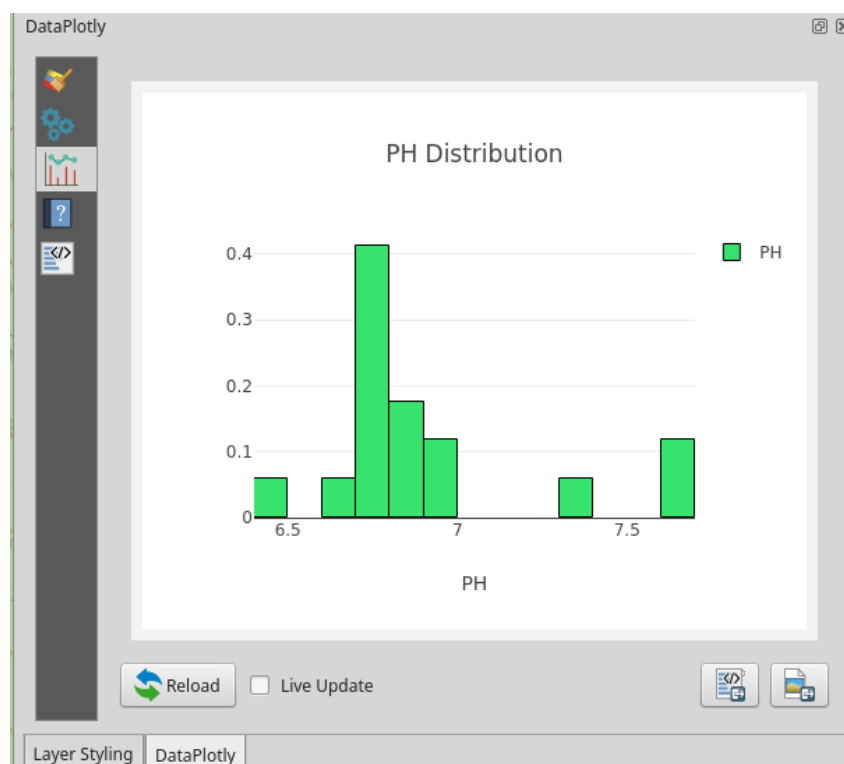
Scatter Plots



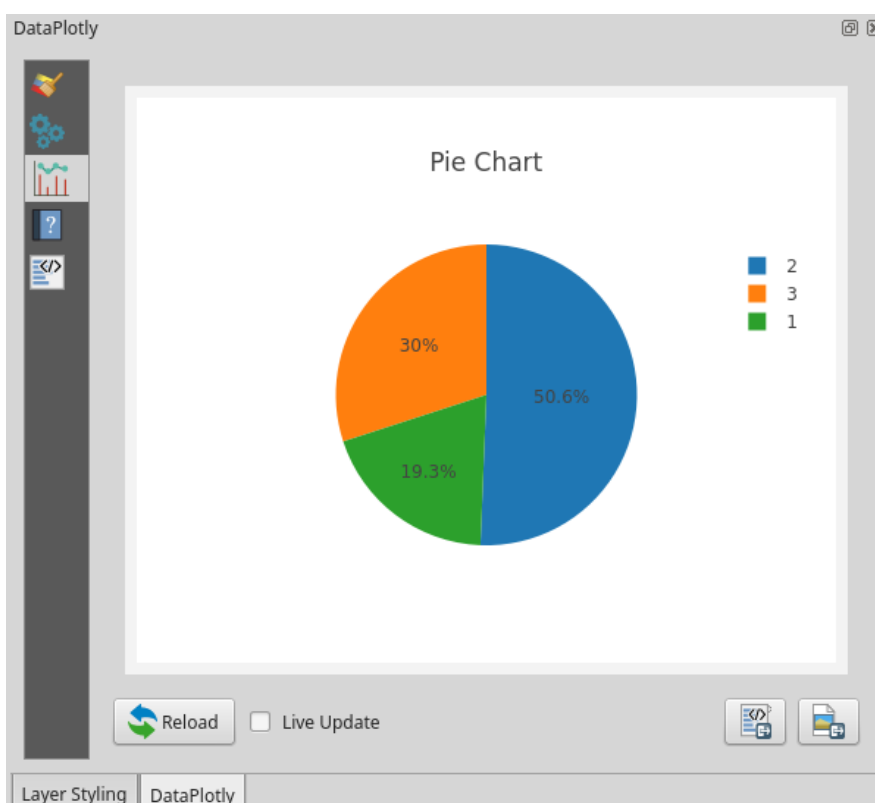
Box Plot with Statistics



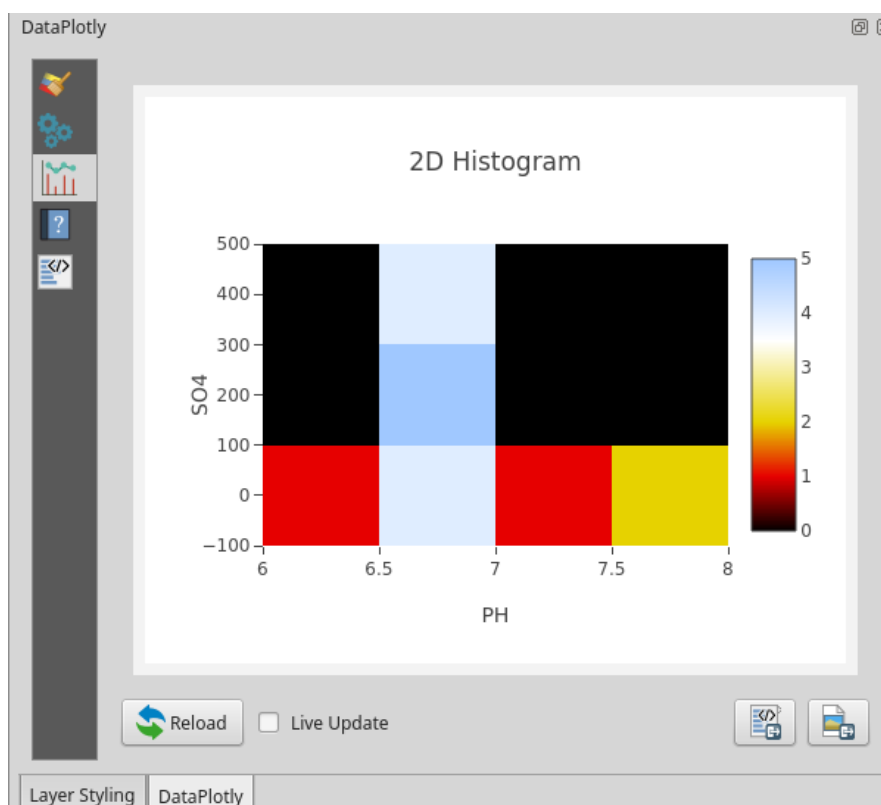
Stacked Bar Plot



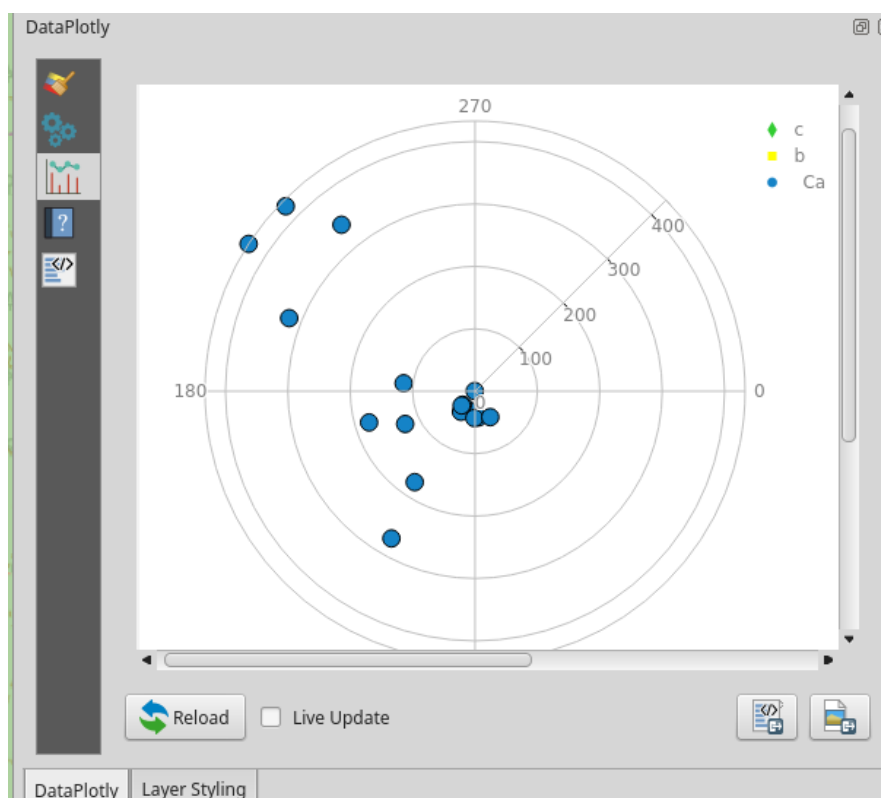
Probability Histogram



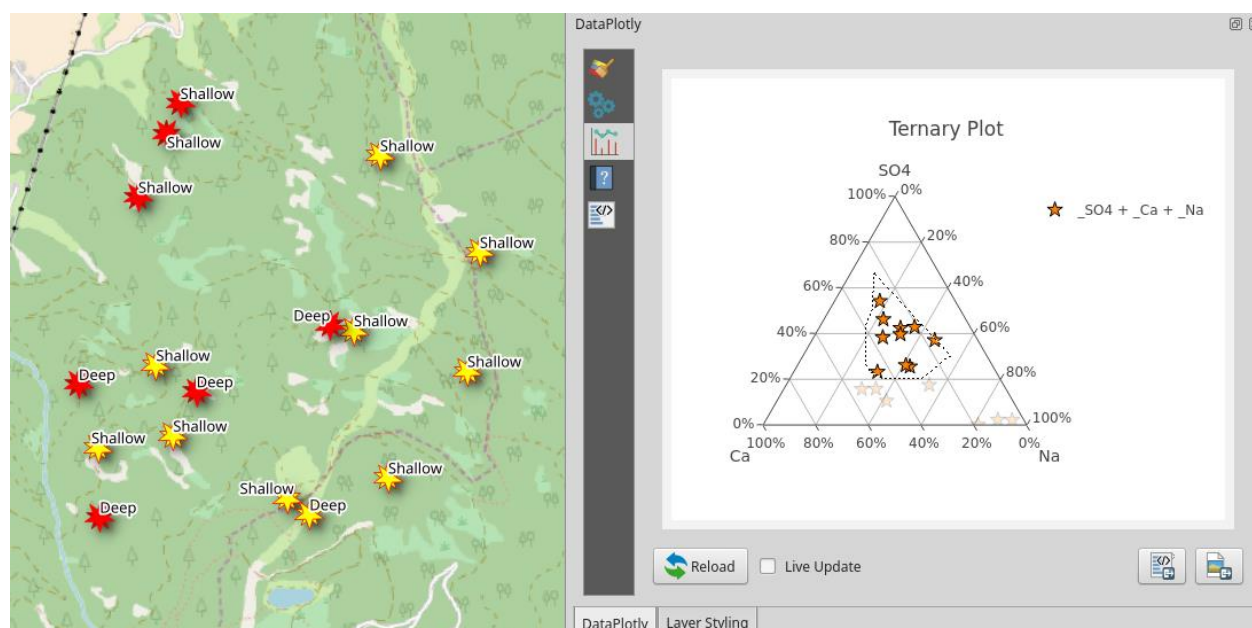
Pie Charts



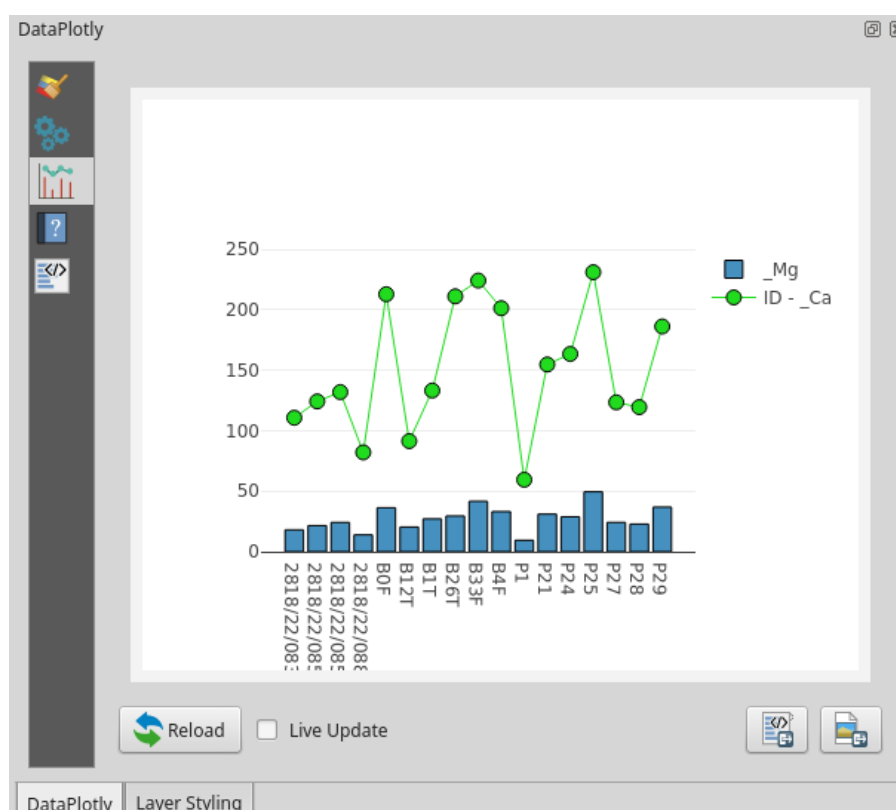
2D Histogram



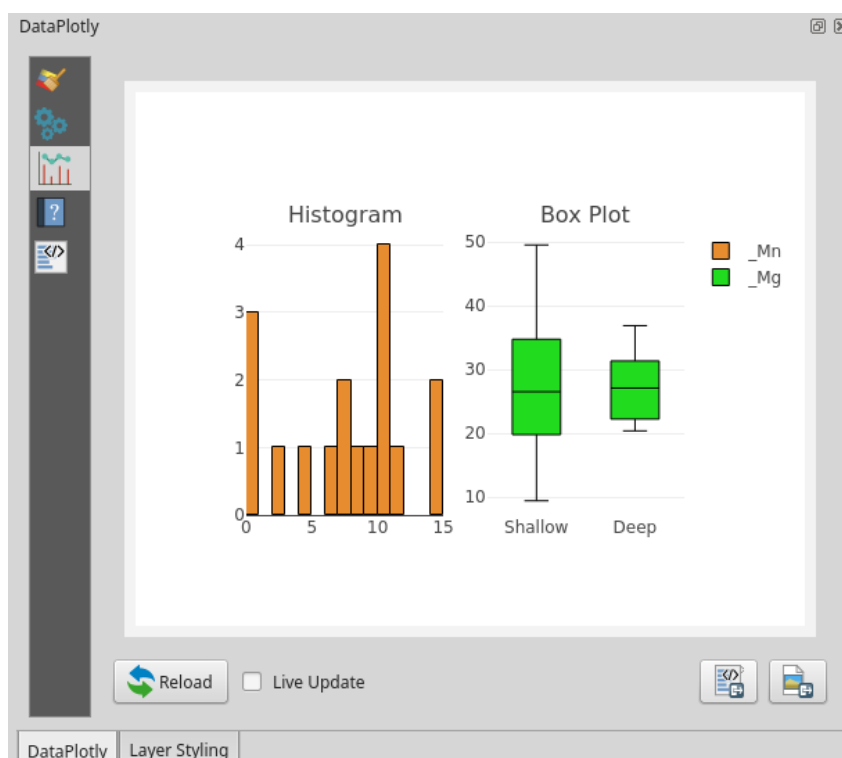
Polar Plots



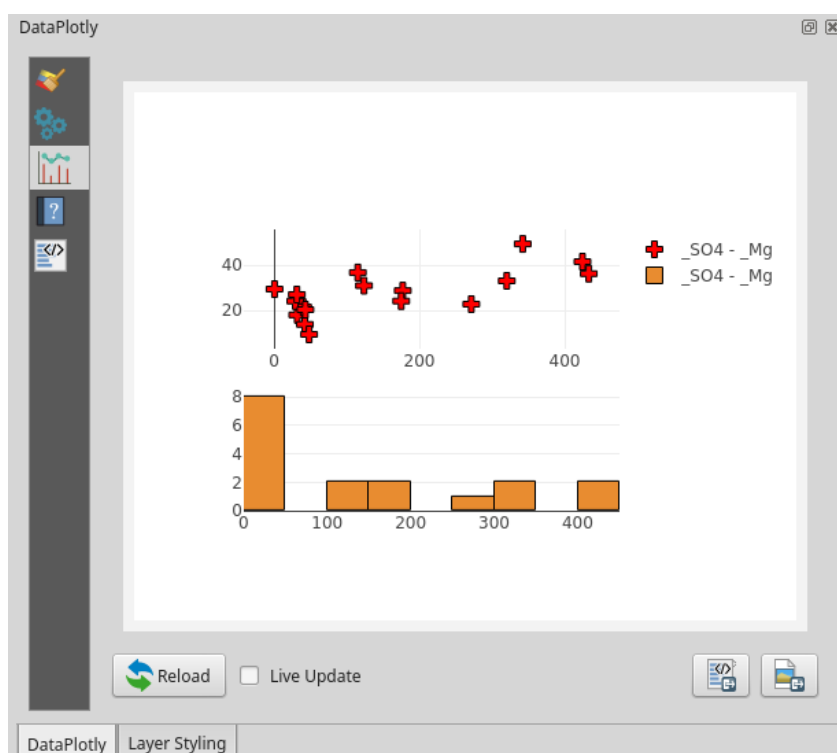
Ternary Plots



Overlapped Plots



Subplots in Columns



Subplots in rows

The html code is available to allow these plots to be added to other documents. The help files are located in the “?” tab of the plugin.



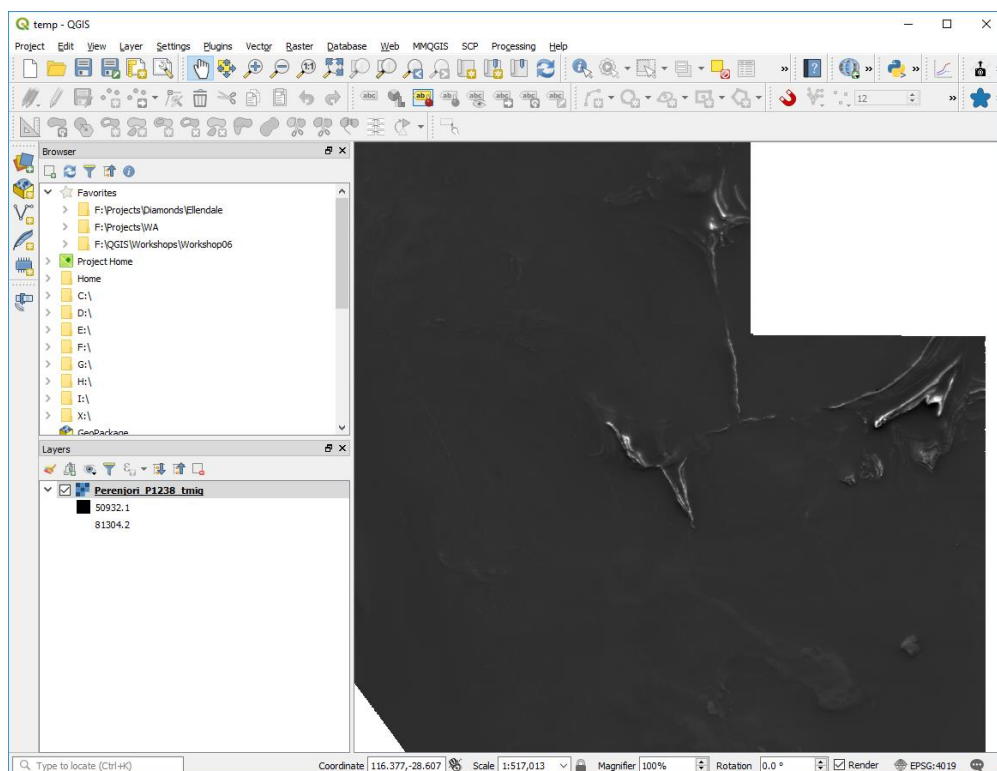
9: GEOPHYSICAL DATA IMPORT AND DISPLAY

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).

When opening located data text files, remember that shape files can only have column names up to 10 characters in length. If your text files have longer column names, then it is suggested you use a free text editor like Notepad++ (<https://notepad-plus-plus.org/>) to modify the field names.

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.

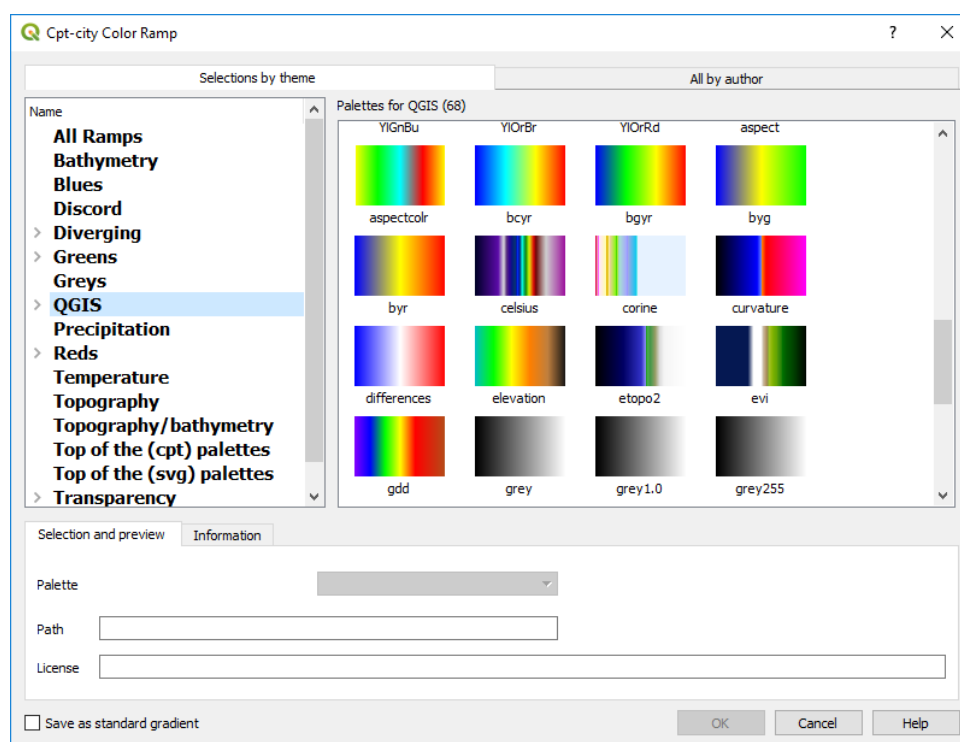


9.2 Colour Ramps

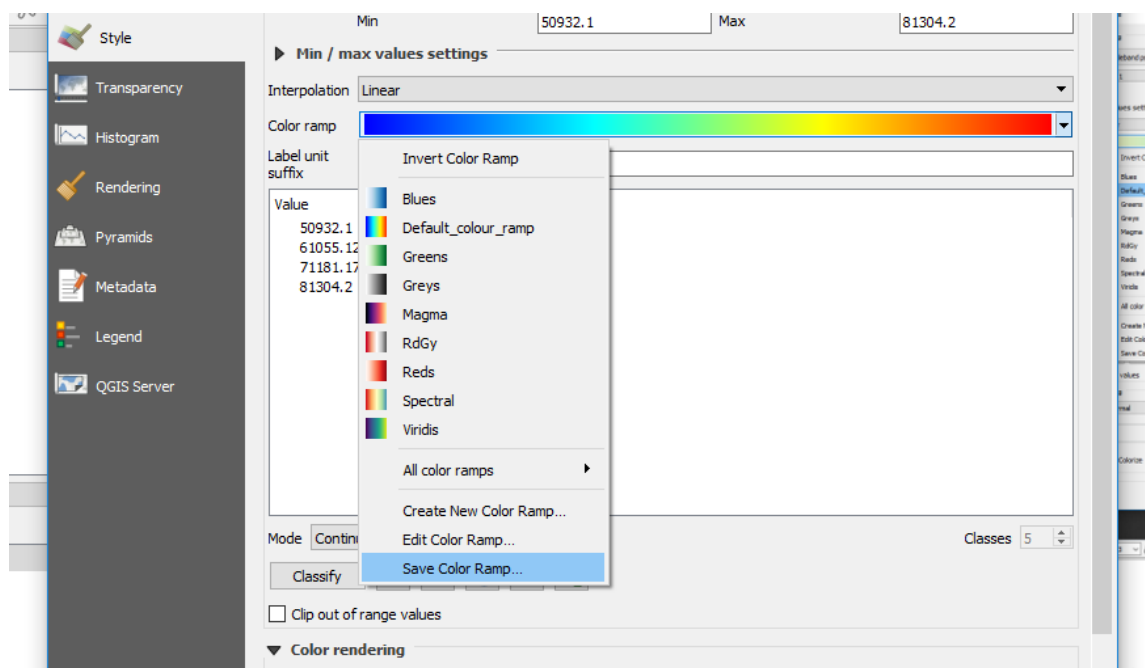
Additional colour ramps are available by clicking on the down arrow to the right of the “Color ramp” dialog box and selecting “Create New Color Ramp...”, select “Catalog: cpt-cty” from the drop-down box to display a variety of available colour ramps.



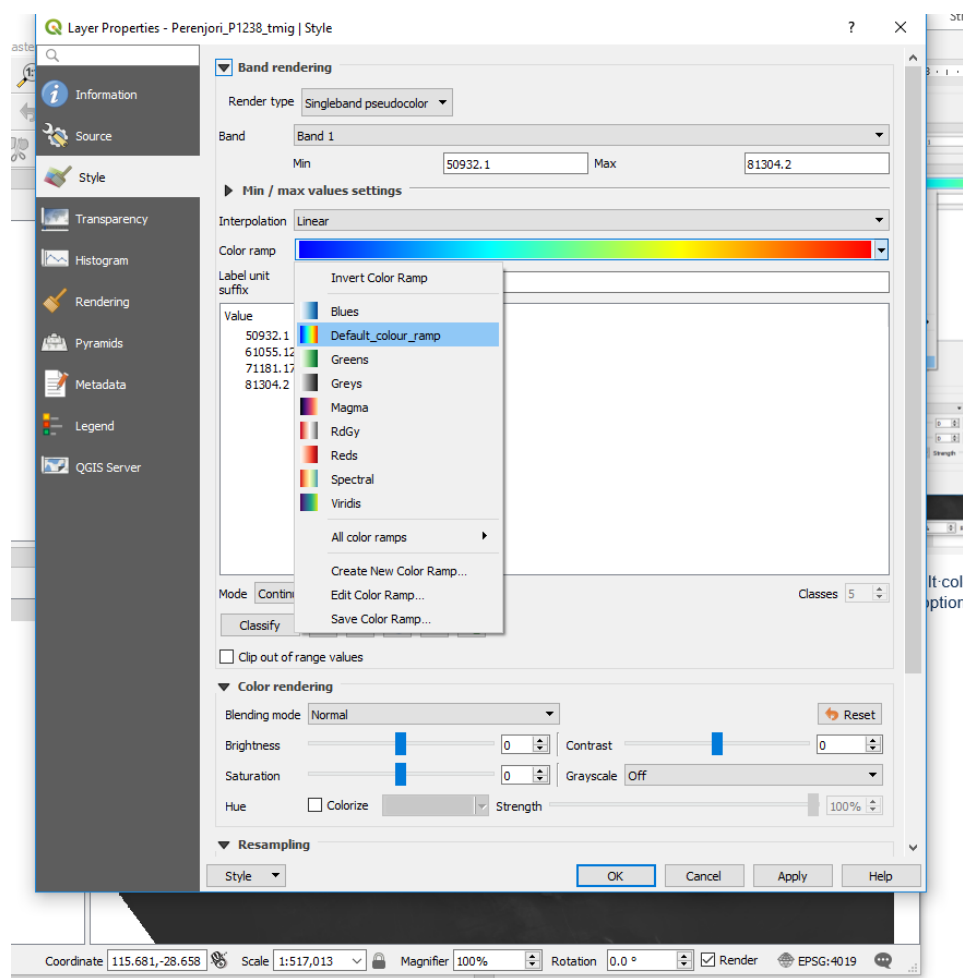
Colour ramps have also been developed by the Centre for Exploration Targeting (CET) in Perth that have better colour perception. These can be reviewed and downloaded from here [“https://peterkovesi.com/projects/colourmaps/”](https://peterkovesi.com/projects/colourmaps/). Download the QGIS xml file and 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” and “bgyr” are also good options 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.

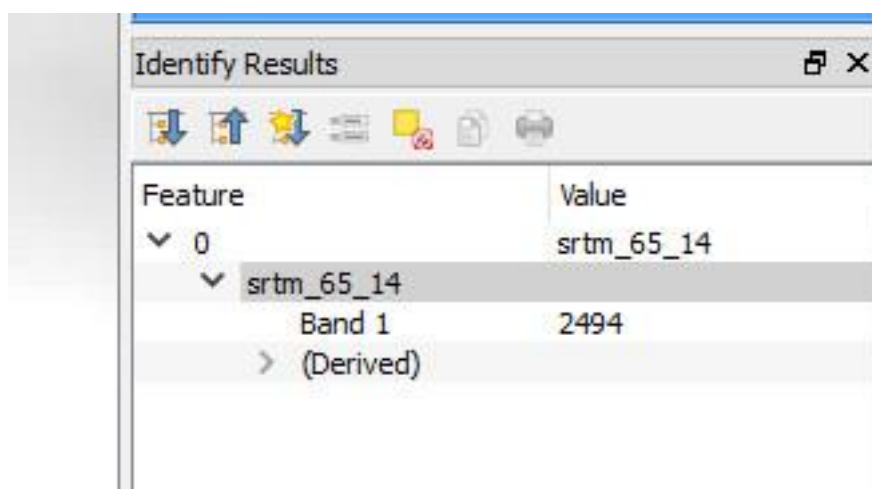


Save the color ramp with a name, e.g. default colour ramp, and “Add to favorites” so it shows up on your quick colour ramp select options.





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.

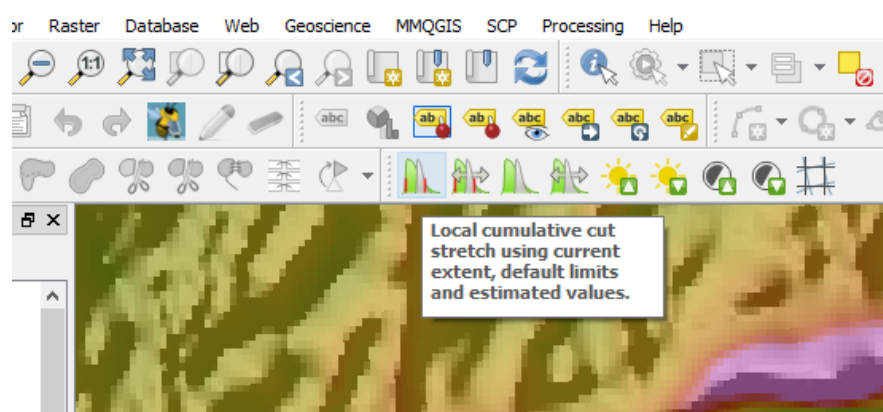


If you open a grid file and have difficulties displaying the data, e.g. with 1VD magnetic images, zoom in to a small area of the grid and then “Stretch to Current Extent” (available as a right click on the layer name in the Layers panel) to stretch the data to something visible.

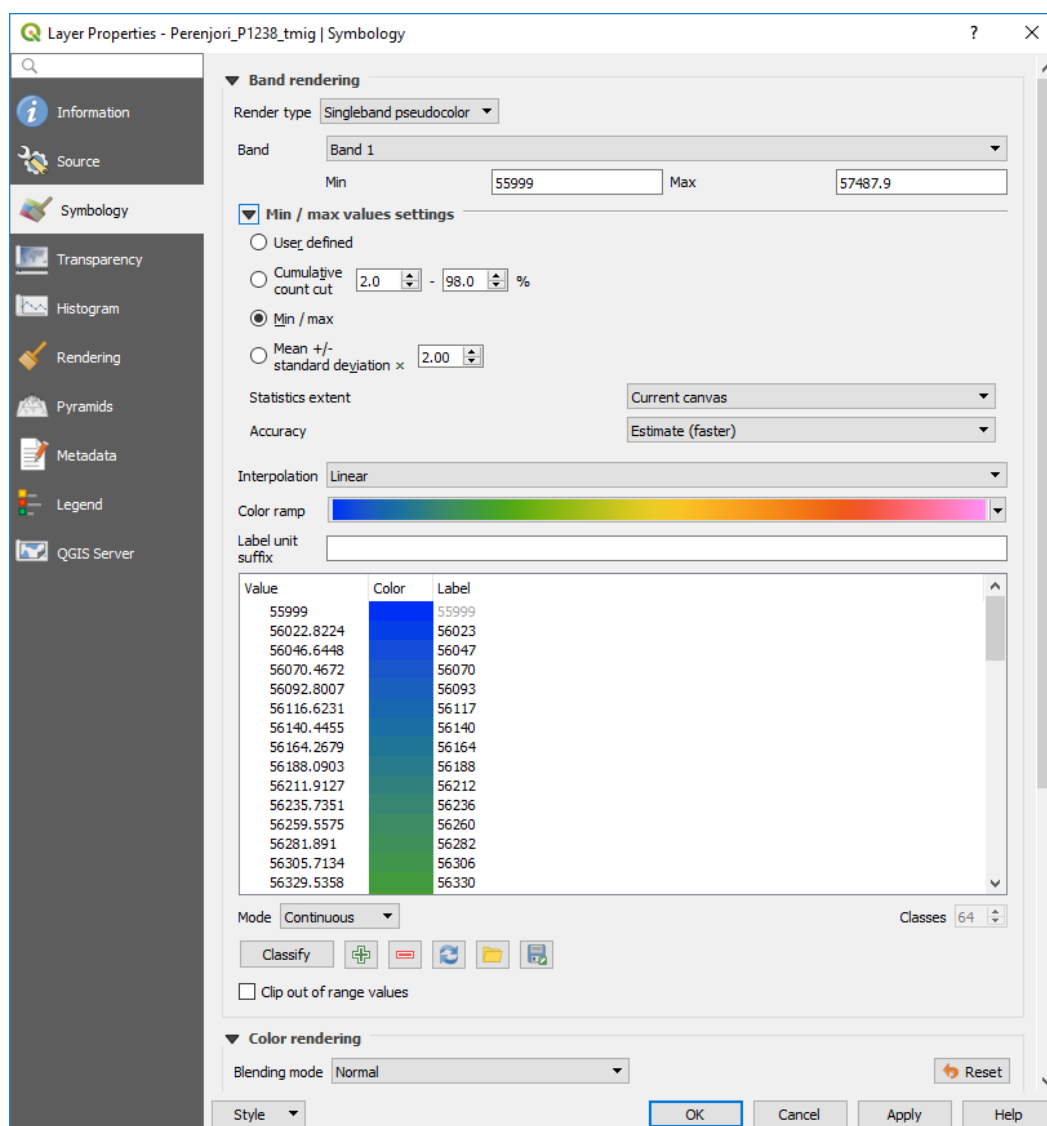
9.3 Custom Data Stretch

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.



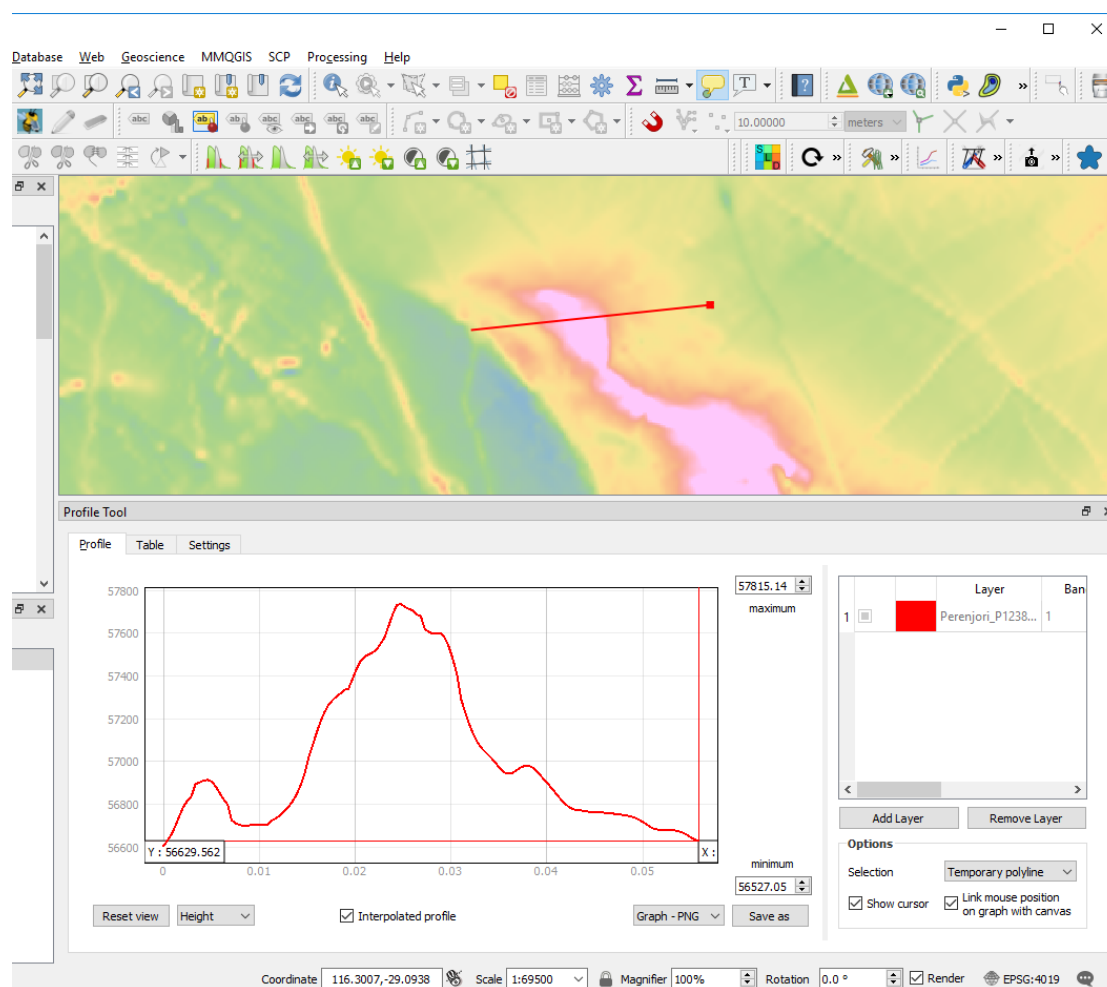
Display settings can also be selected in the Symbology tab of the Layer Properties.



9.4 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.



9.5 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 (<http://www.geoproc.com/qgis.htm>) 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.

Coloured bar scales can also be created for coloured images using the Composer > Create Colour Scale Bar” tool. There are some dependencies that require installation for these to work so please read the installation instructions. The plugin loads the menu items into the Processing Toolbox.



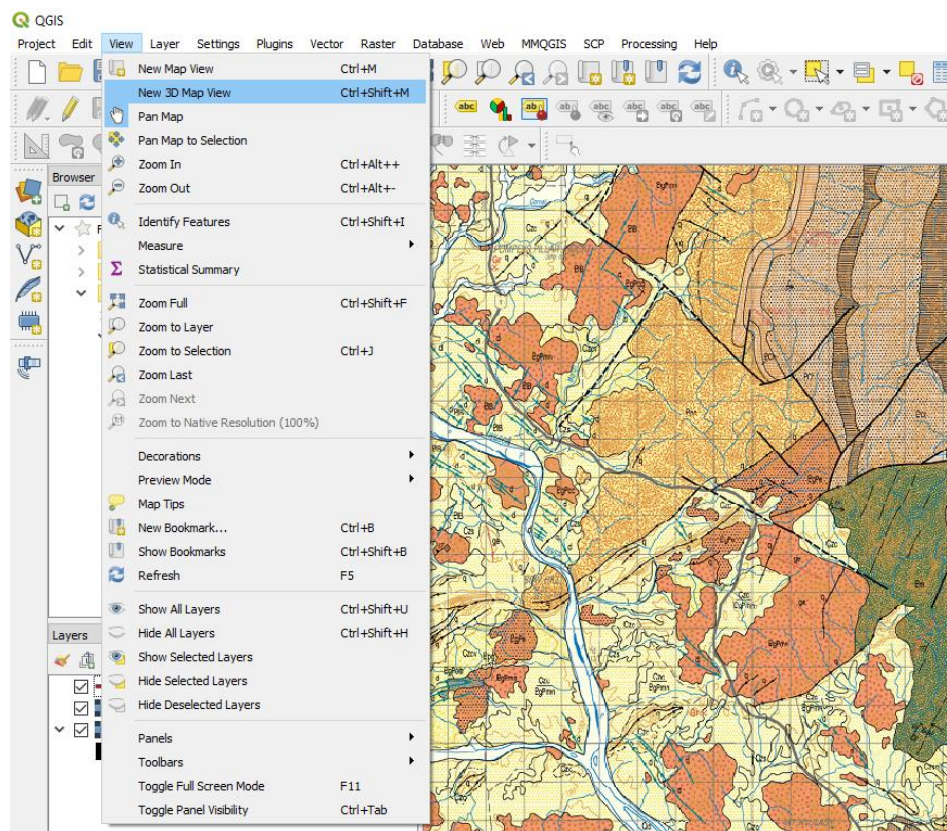
10: 3D IMAGE DISPLAY

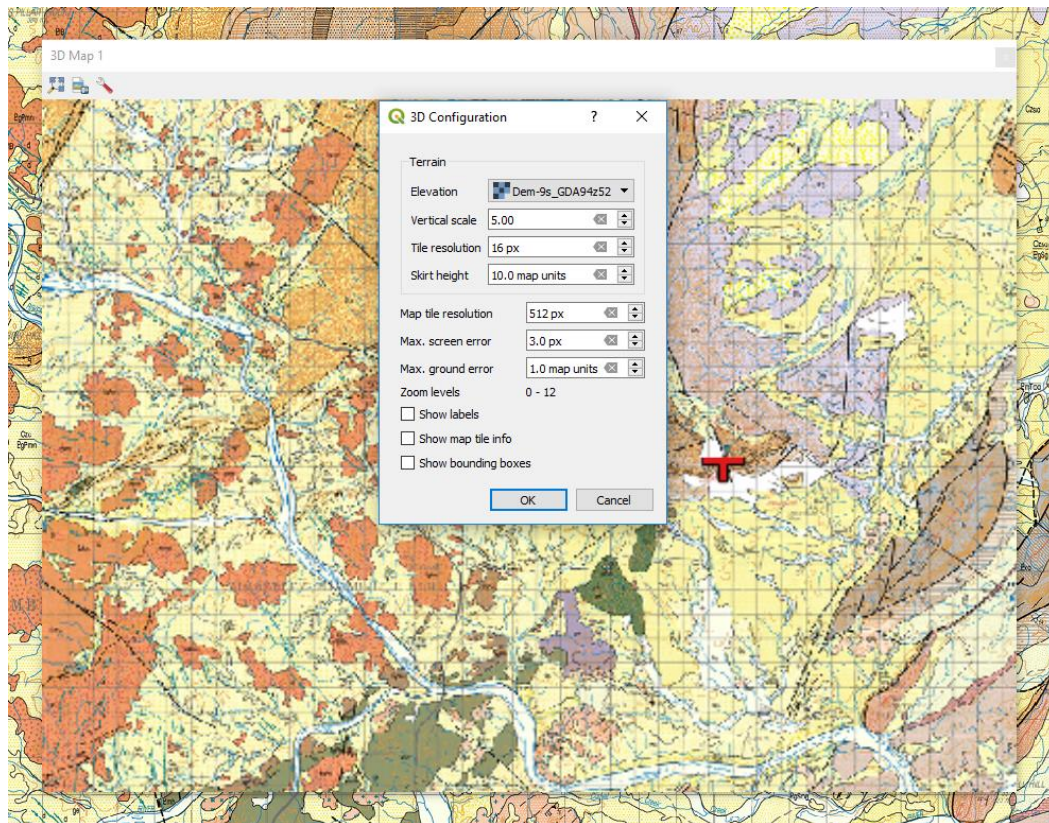
QGIS v3 now has a 3D view capability built in as a standard part of the program (3d Map View) or by using the QGIS2threejs plugin. The options for the 3D Map View are limited at this time but a recent crowd funding effort has enabled planning and extra programming for the 3D options to be greatly improved. 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

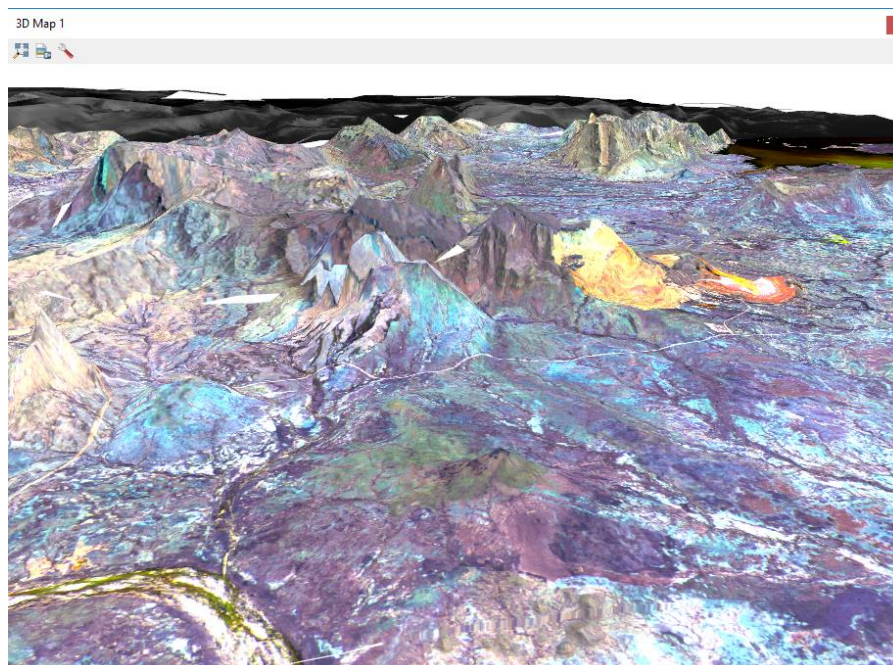
The layers require to be projected, i.e. not a geographic projection, lat/long, and they should all be in the same projection.

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.



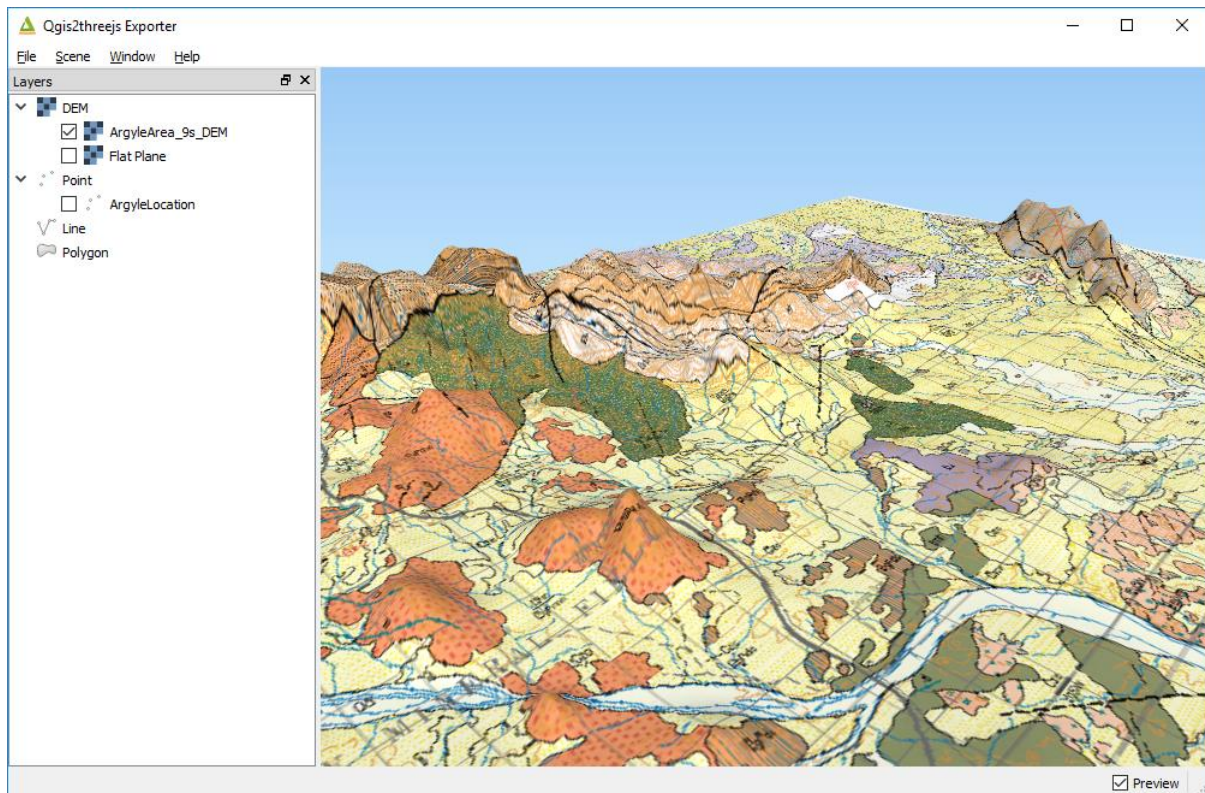
Any image displayed in the map window can be used for 3D display.



10.2 QGIS2Threejs Plugin

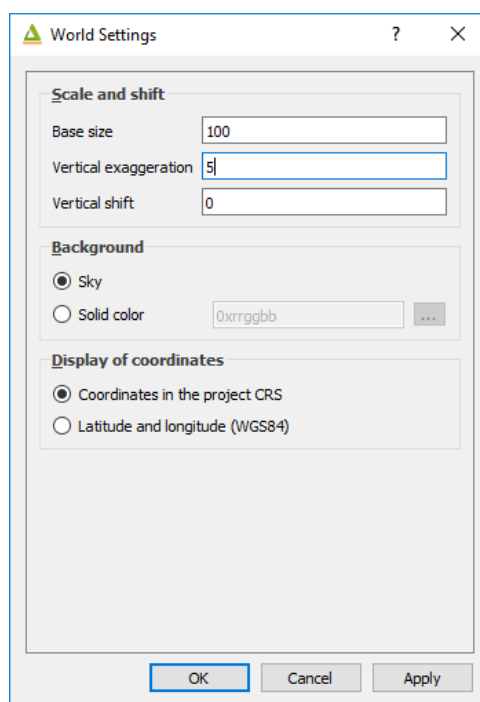
This plugin is more flexible than the 3D map view at the present stage of its development for geological application. The layers require to be projected, i.e. not a geographic lat/long projection, and they should all be in the same projection. If you have data in 3D, i.e. with x, y and z coordinates, 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

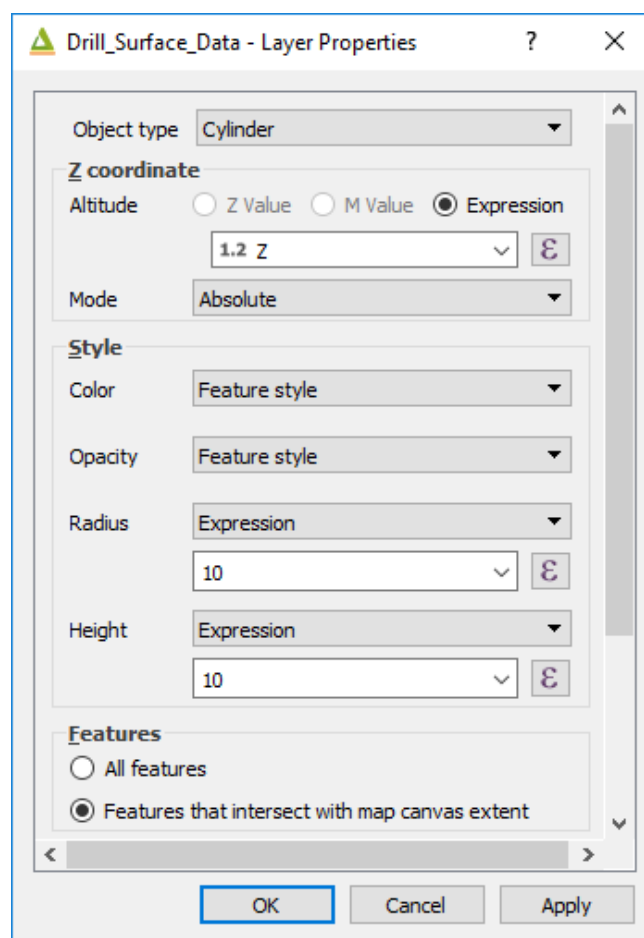


Make sure the grid is on the bottom, with the layers to be draped on top of the DEM/grid layer. Run the QGIS2Threejs plugin and select the DEM layer.

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

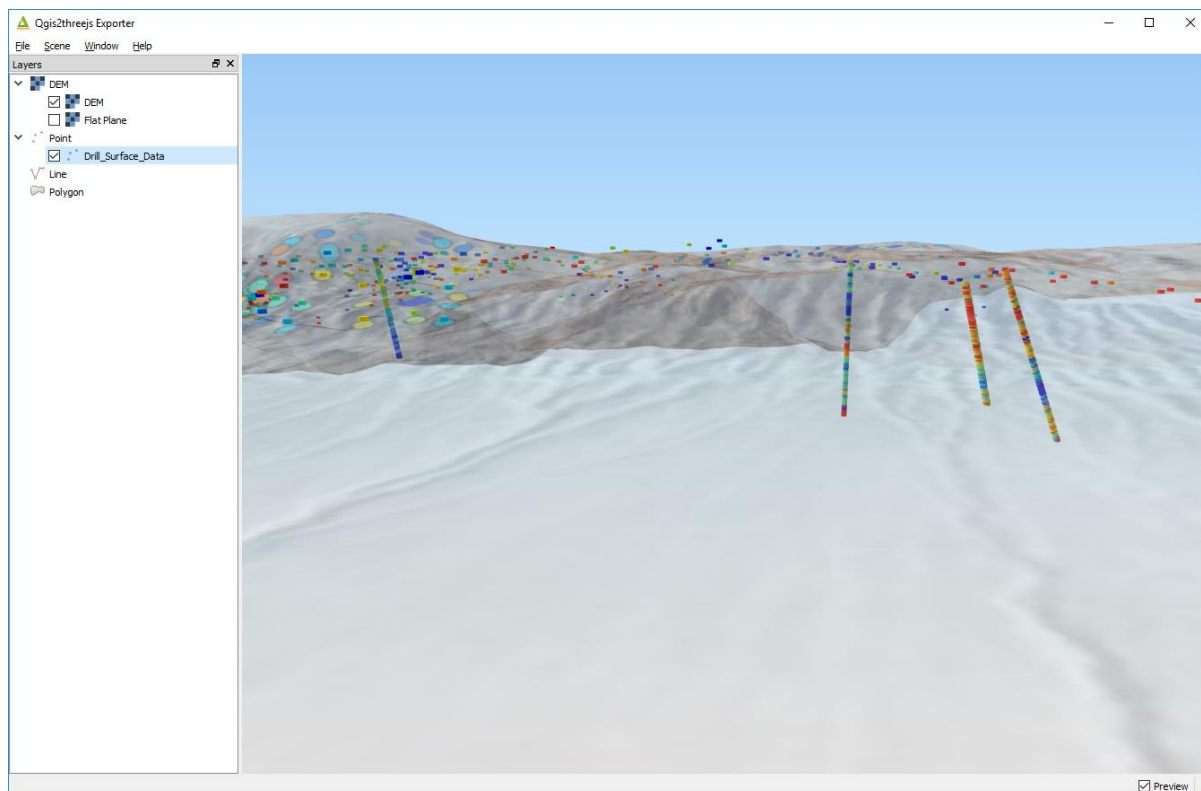


If you have vector data with a z (e.g. RL or elevation data) then right click on the vector layer name in the QGIS2Threejs window and select the z value to use in the “Z Coordinate” options. Downhole drill hole data can be plotted using this method.





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.





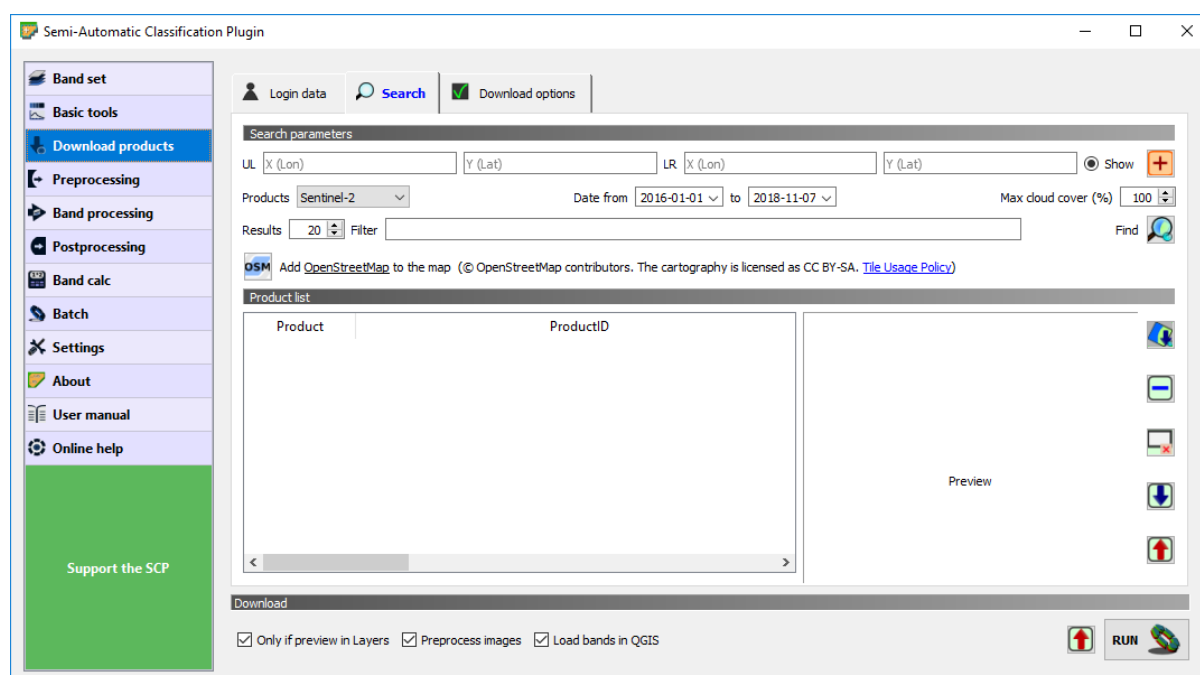
11: REMOTE SENSING

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 (<https://www.youtube.com/watch?v=GFrDgQ6Nzqs>) 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 and Sentinel data.

11.1 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://fromgistors.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.

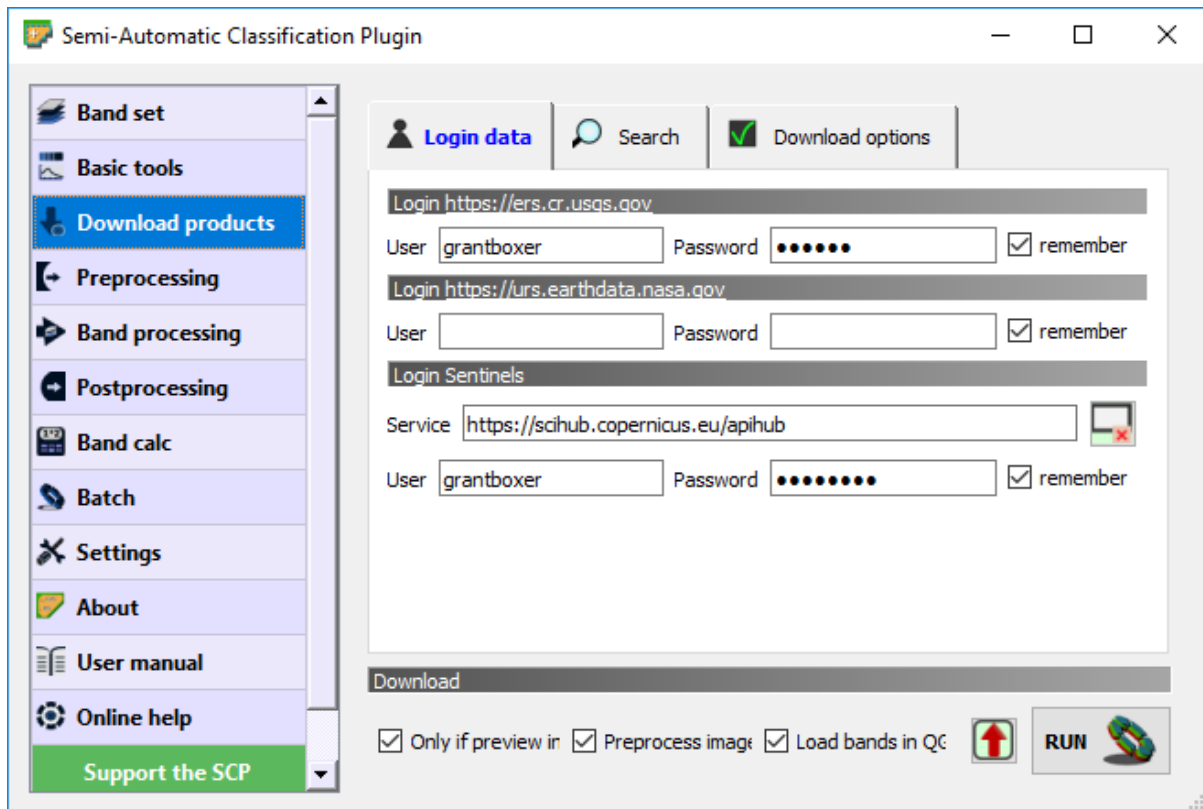


The main SCP window shows tabs for downloading data, as well as a variety of other pre and post processing options, band calculations and tools for land cover classification.

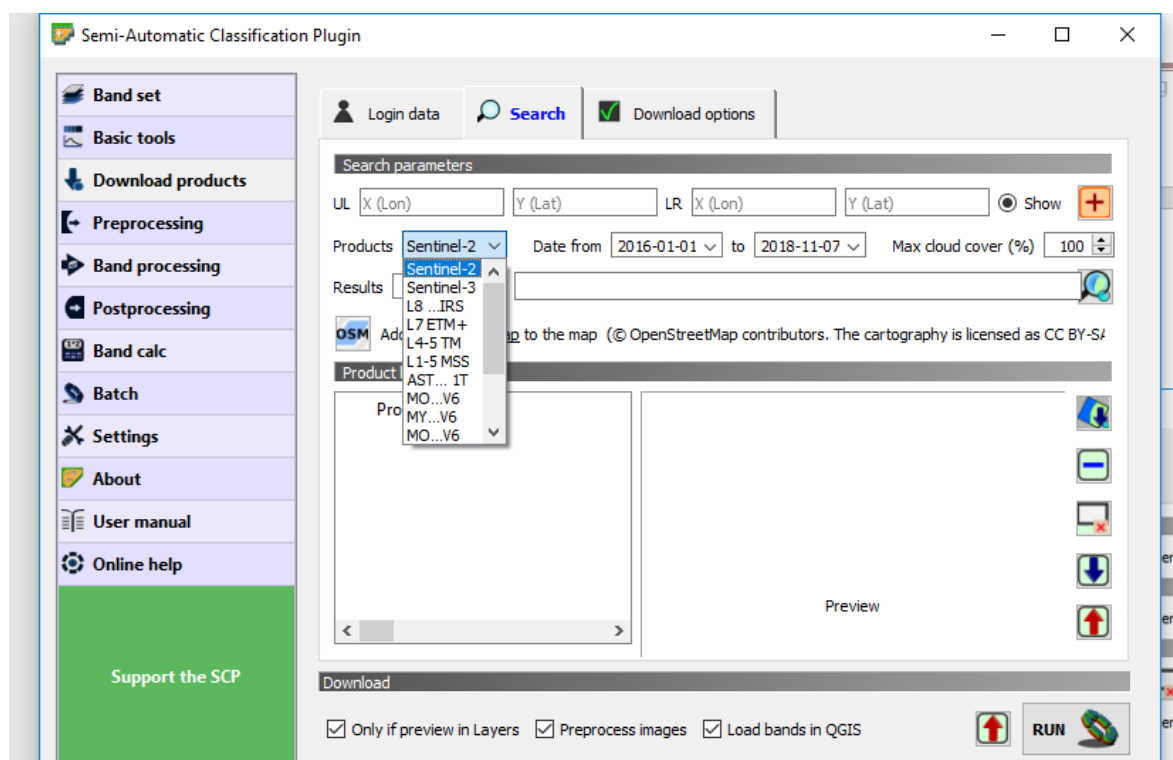
To download data you need to register with the USGS via their EarthExplorer portal (free registration, <http://earthexplorer.usgs.gov/>) for ASTER and Landsat data and with the European Space Agency (ESA) via their Sentinel data access portal (<https://sentinel.esa.int/web/sentinel/home>). Enter these login details into the relevant sections of the SCP Download Products > Login data tab. Make sure you click “Remember” so you don’t have



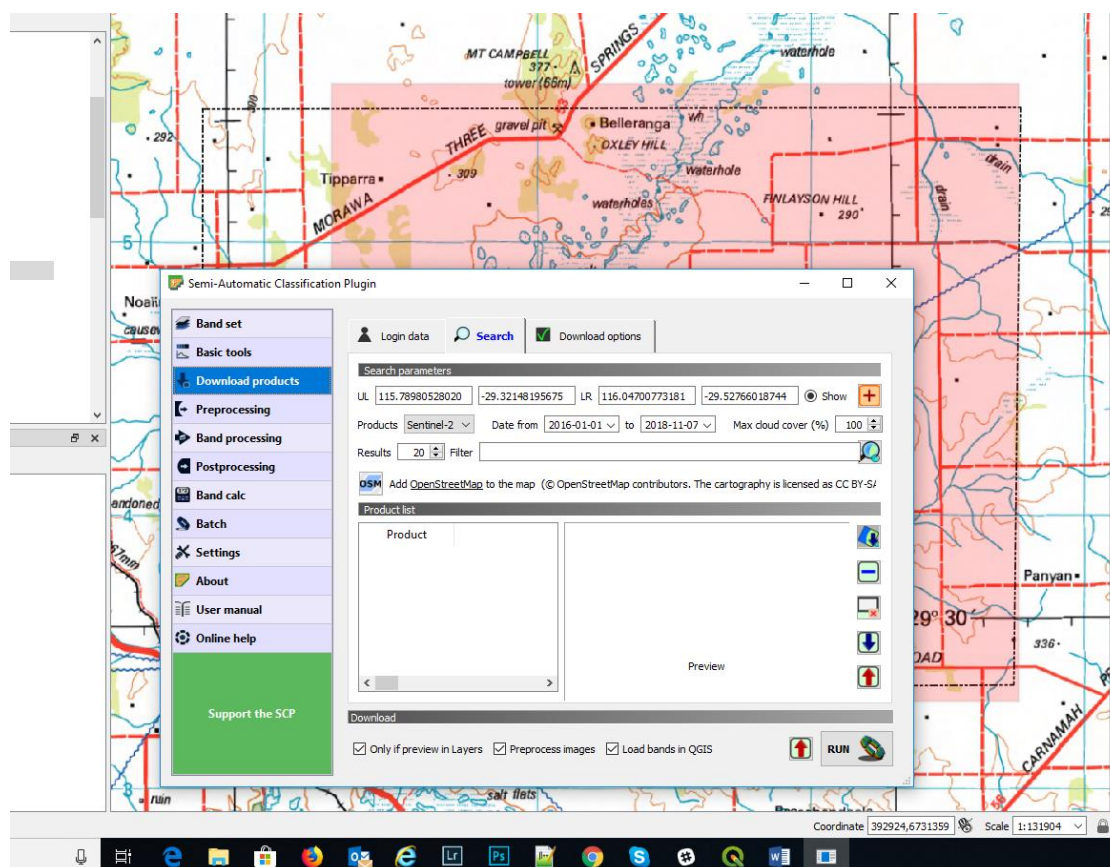
to re-enter your login details each time. Note also that logins with ESA make take a couple of days to initialise.



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.



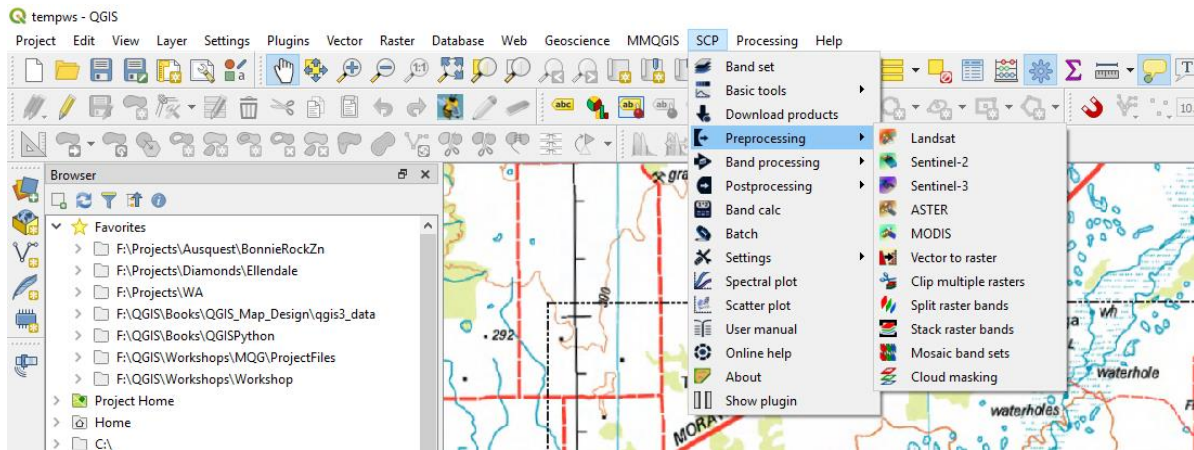
The required product can be selected via the “Products” dropdown list. To select a search area, click on the orange-red cross in the top RHS of the window, then left click the top left hand side of the map area, then right click on the lower right hand side to set your search area. This will then populate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





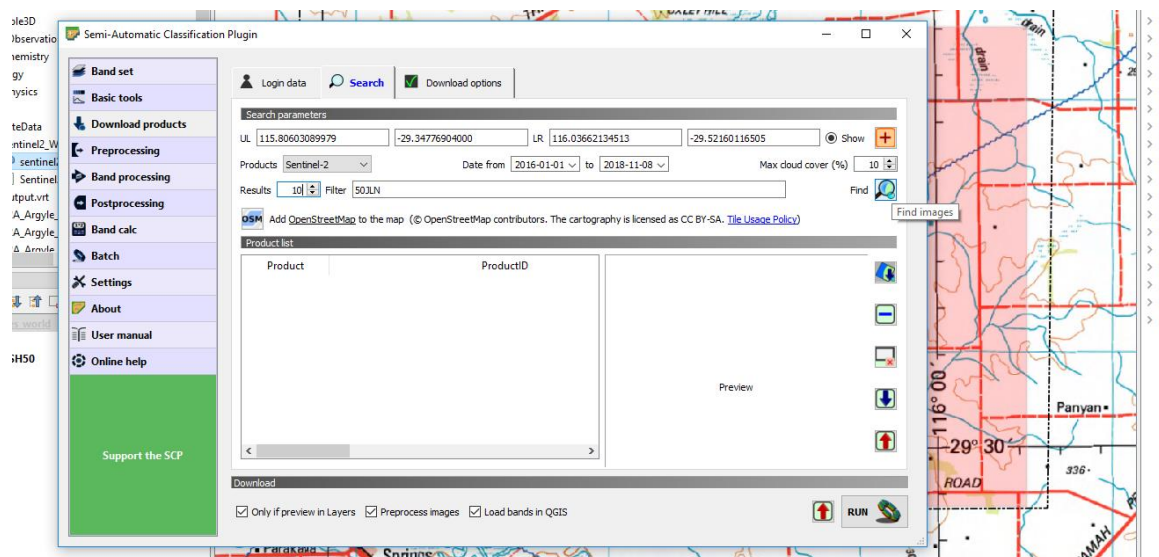
You can further refine your data search by entering for example a Sentinel 2 tile number into the “Filter” window to speed up searching and ensuring you only download the required tiles. You can select the maximum allowable cloud cover and any date ranges. Note that for ASTER data only download data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

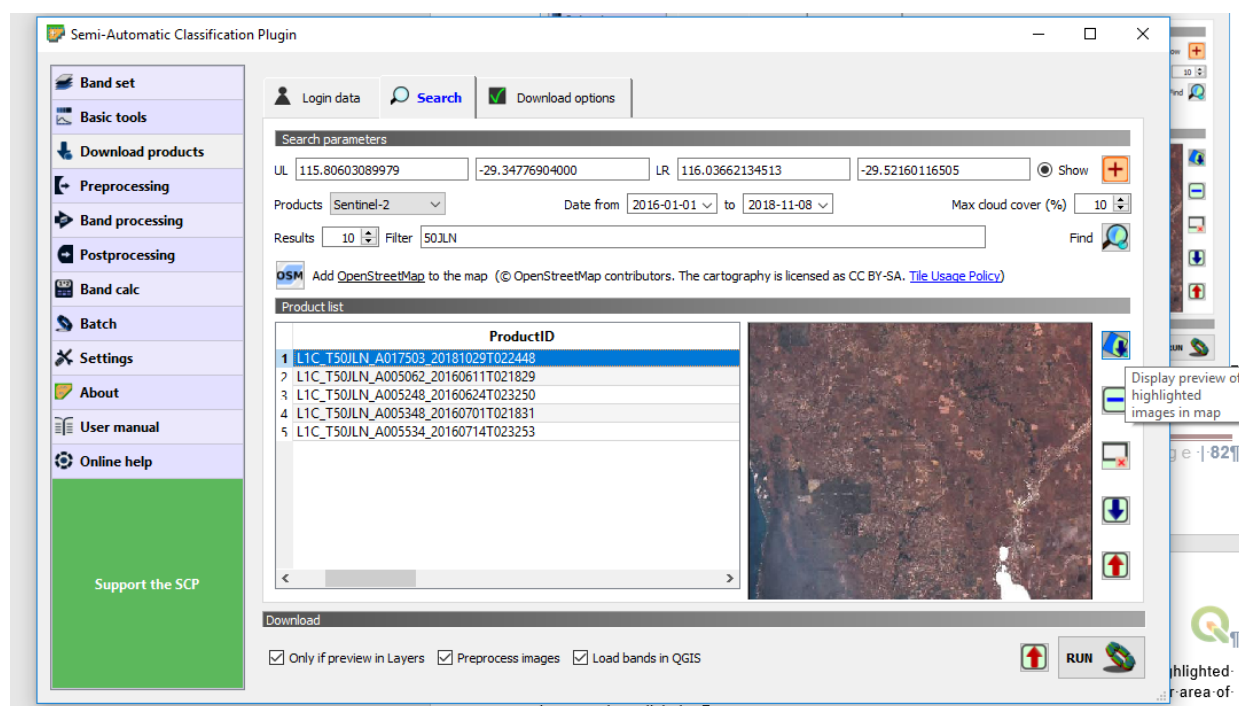


The Preprocessing window allows SCP to do atmospheric and other adjustments to the source satellite data after download, e.g. DOS 1 atmospheric correction on Sentinel 2 data. Note that preprocessing will only occur if the “Preprocess Images” check box is ticked in the Download window. Note also the other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

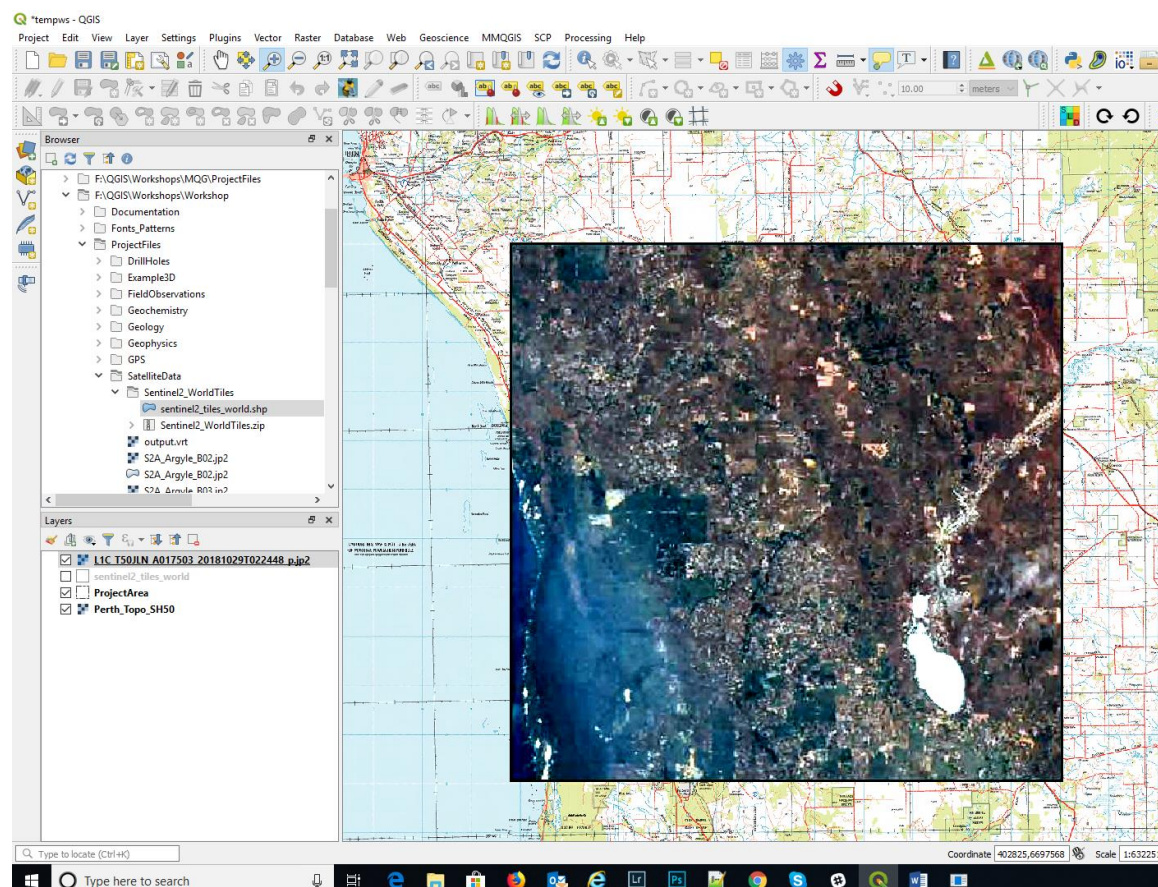
Once you have set your search parameters, click the “Find” icon.



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. 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.

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).

11.2 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).

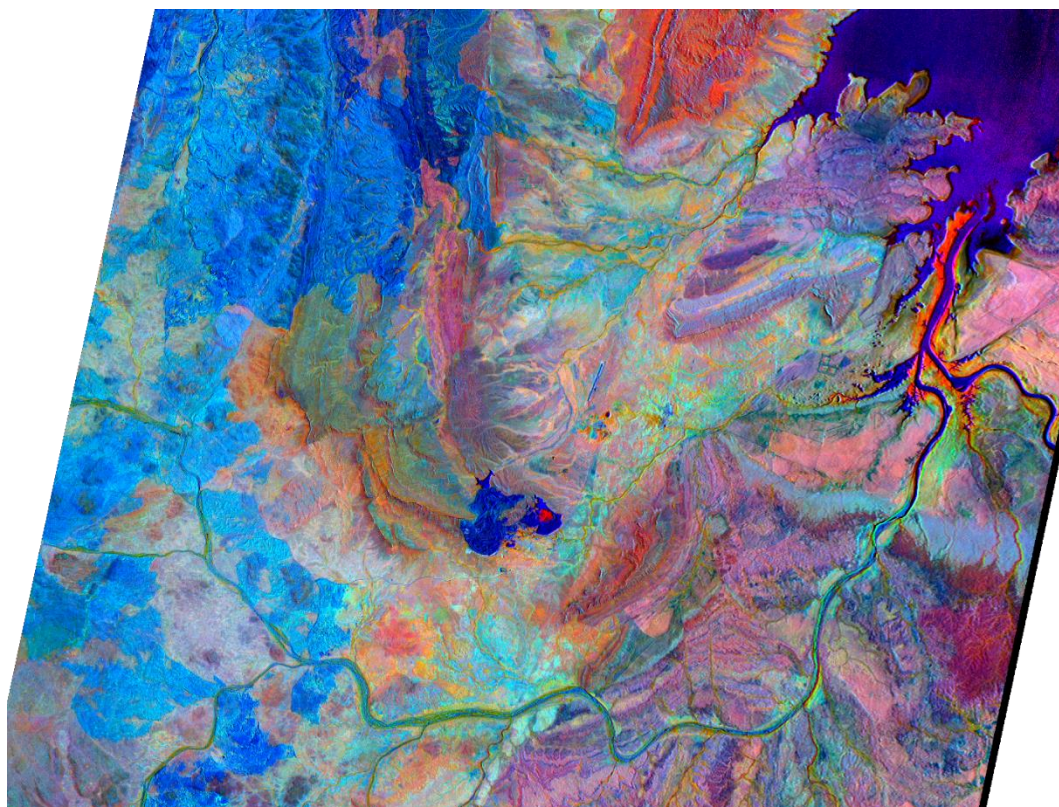
ASTER data is now freely available worldwide but note that the SWIR sensor (bands 4 to 9) became inoperable on 1st April 2008, and therefore only data acquired before this time will be suitable for mineral mapping.

ASTER Users Handbook



Subsystem	Band No.	Spectral Range (μm)	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	
AIOH minerals/advanced argillic alteration***	5/6 (phen)	7/6 (musc)	7/5 (kaol)	Hewson (CSIRO)
Clay, amphibole, laterite	(5x7)/6 ² (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)	
Decorrelation (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 ²⁺	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 AIOH 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
Iron			
Ferric iron, Fe ³⁺	2/1		Rowan; CSIRO
Ferrous iron, Fe ²⁺	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
Carbonates / Mafic Minerals			
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
Silicates			
Sericite / muscovite / illite / smectite	(5+7)/6	Phyllic 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	(5+7)/6 ²		Bierwith
Alteration	4/5		Volesky
Host rock	5/6		Volesky
Silica			
Quartz rich rocks	14/12		Rowan
Silica	(11+11)/10/12		Bierwith
Basic degree index (gnt, cpx, epi, chl)	12/13	Exoskarn (gnt, px)	Bierwith, CSIRO
SiO ₂	13/12	Same as 14/12	Palomera
SiO ₂	12/13		Nimoyima
Siliceous rocks	(11+11)/(10+12)		Nimoyima
Silica	11/10		CSIRO
Silica	11/12		CSIRO
Silica	13/10		CSIRO
Other			
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



Mineral Indices of Ninomiya (2004)

OH Minerals Index – $(\text{Band 7} / \text{Band 6}) * (\text{Band 4} / \text{Band 6})$

Kaolinite Index – $4/5 * 8/6$

Alunite Index – $7/5 * 7/8$

Calcite Index – $6/8 * 9/8$

Porphyry Alteration Index – 4, 6 and 8 and RGB (advanced argillic and phyllic alteration in pink to red colours)

Alunite and kaolinite enhanced by 4/5 or 4/6

Sericite – phyllic alteration enhanced by 5/6

Propylitic alteration enhanced by 5/8

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.

11.3 Landsat Data

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

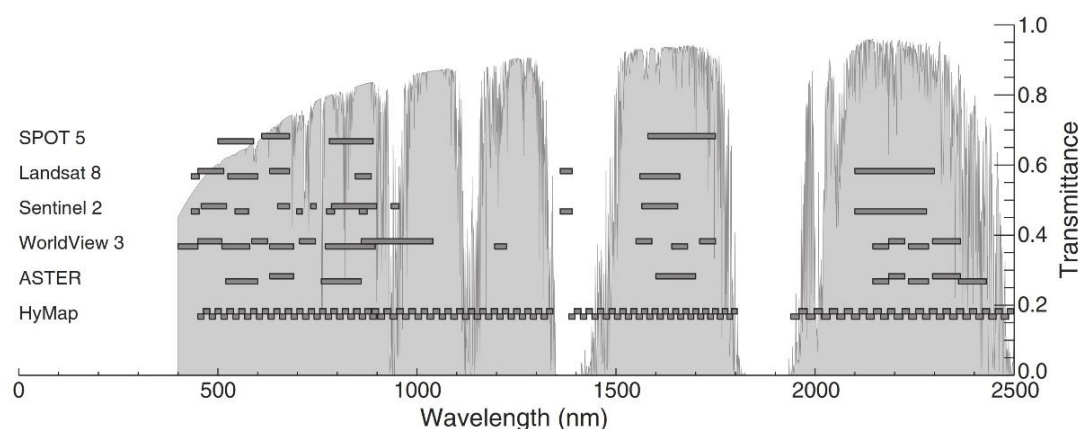
Band Reference Number	Band Description	Band Center (nm)
1	Coastal Aerosol (Operational Land Imager (OLI))	433
2	Blue (OLI)	482
3	Green (OLI)	562
4	Red (OLI)	655
5	Near-Infrared (NIR) (OLI)	865
6	Short Wavelength Infrared (SWIR) 1 (OLI)	1610
7	SWIR 2 (OLI)	2200
8	Panchromatic (OLI)	590
9	Cirrus (OLI)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



11.4 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 (<https://sentinel.esa.int/web/sentinel/home>) 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.

The following list of recommended band combinations is from the Sentinel education web page (<https://Sentinel-hub.com/develop/education>).

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

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.

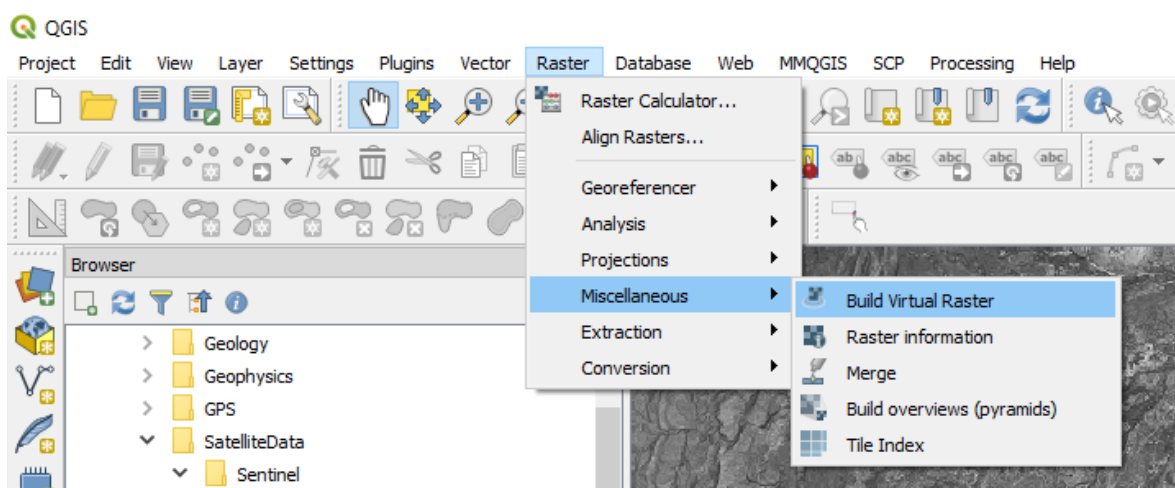
Feature	ASTER	Sentinel-2
Iron		
Ferric Iron, Fe ³⁺	2/1	4/3
Ferrous Iron, Fe ²⁺	5/3 + 1/2	12/8 + 3/4
Laterite	4/5	11/12 ^a
Gossan	4/2	11/4
Ferrous silicates (Biotite, chloride, amphibole)	5/4	12/11 ^a
Ferric oxides	4/3	11/8
Carbonates/Mafic minerals		
Carbonate/Chlorite/Epidote	(7 + 9)/8	–
Epidote/Chlorite/Amphibole	(6 + 9)/(7 + 8)	–
Amphibole/MgOH	(6 + 9)/8	–
Amphibole	6/8	–
Dolomite	(6 + 8)/7	–
Silicates		
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 ²	–
Alteration	4/5	11/12 ^a
Host rock	5/6	–
Other		
Vegetation	3/2	8/4
NDVI	(3 – 2)/(3 + 2)	(8 – 4)/(8 + 4)

^a ASTER bands 5–7 fall within band 12 of Sentinel-2.

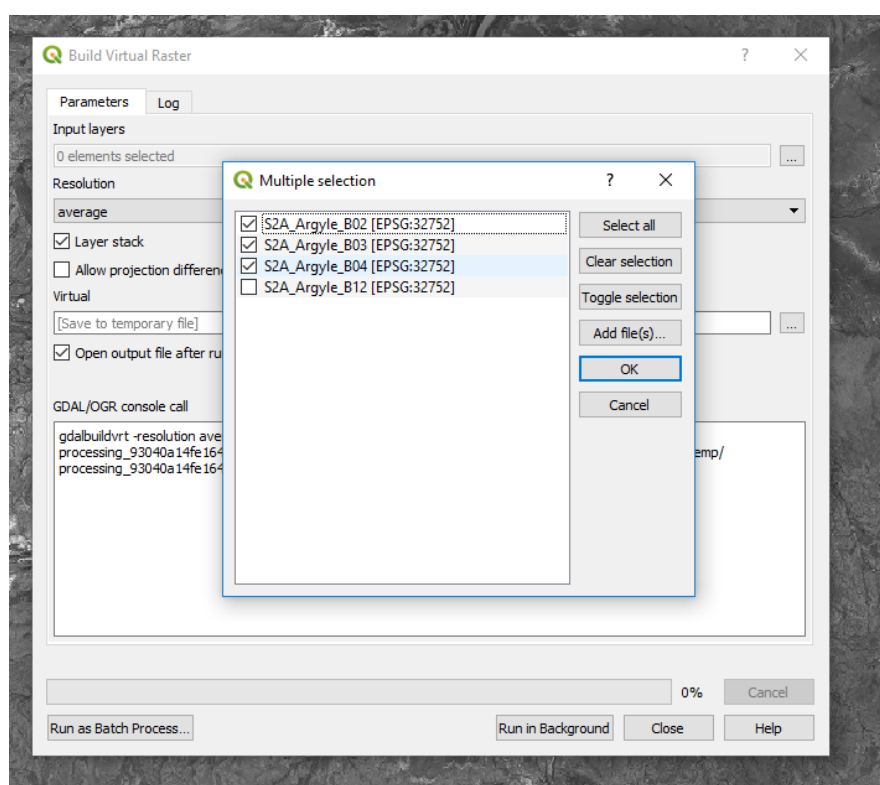
11.5 Creating RGB Images

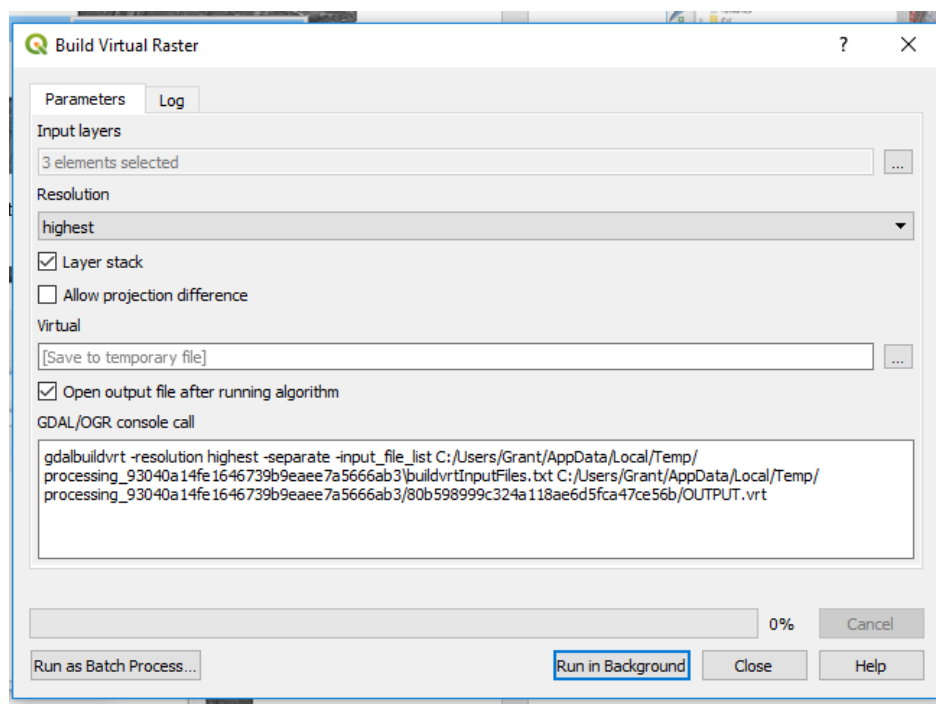
There are two methods available to create a coloured image (“rgb”) of remote sensing or any other 3 band data set. We can use the Raster > Miscellaneous > Build Virtual Raster option or the “Virtual Raster Builder” plugin. Ensure you have the files in the correct order as it assigns the red channel to the lowest image, green to the middle image and blue to the upper image in the Browser panel.

The Raster option is shown below.



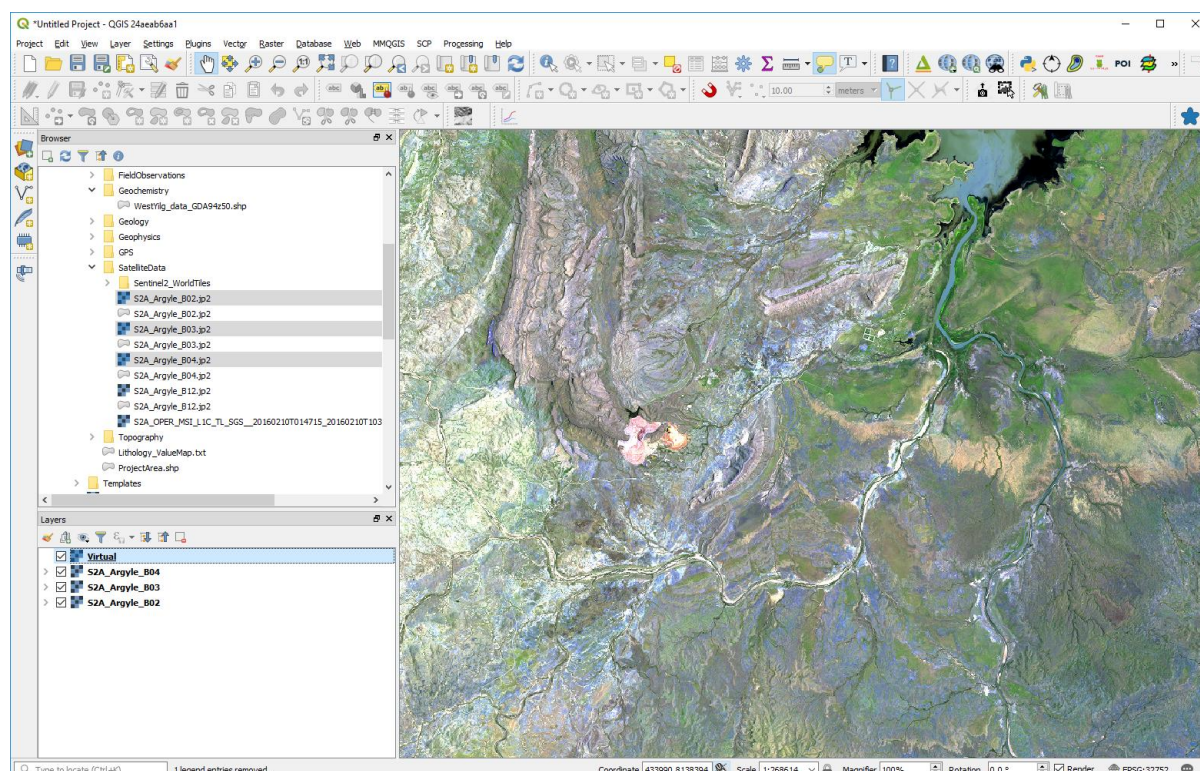
The Build Virtual Raster window will be displayed. Select the input layers as the ones to use for the RGB composite.





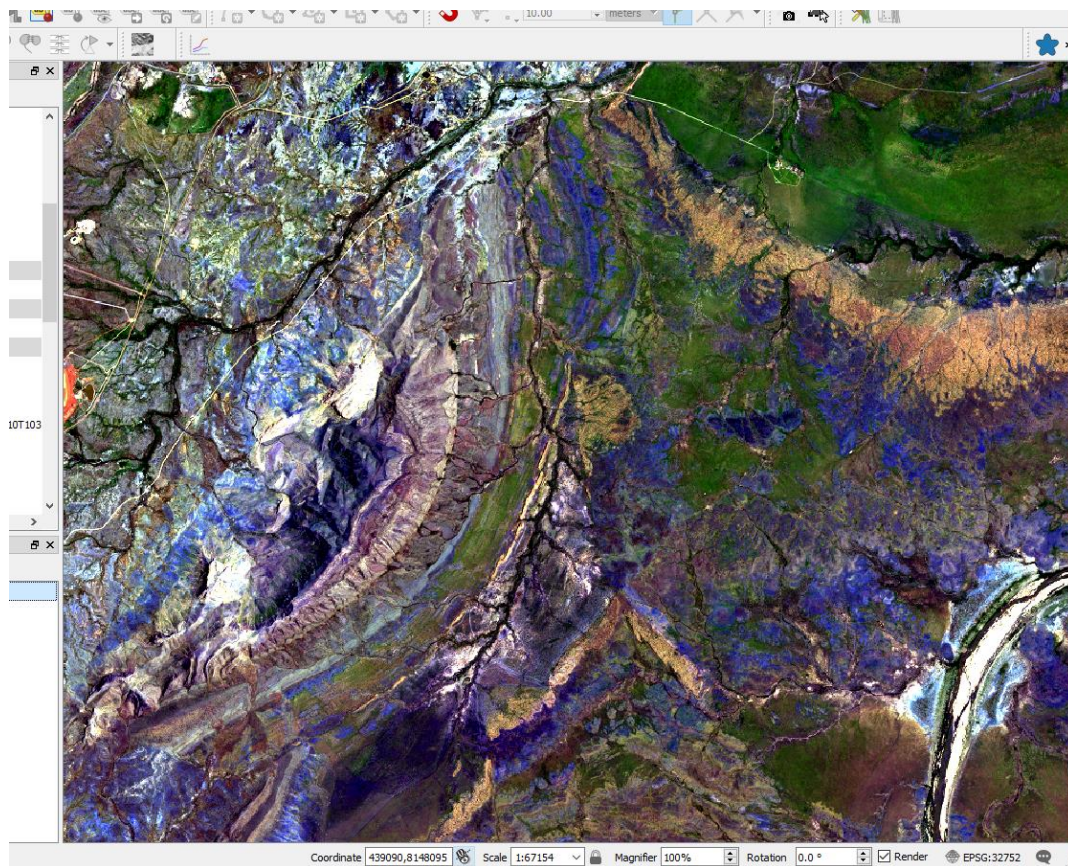
Select the “Highest” resolution to ensure you obtain the highest resolution possible and is similar to “pansharpening” where the larger pixels will be resampled to match the smaller pixels. Press “Run in Background” and the composite colour image will be produced as a virtual image.

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



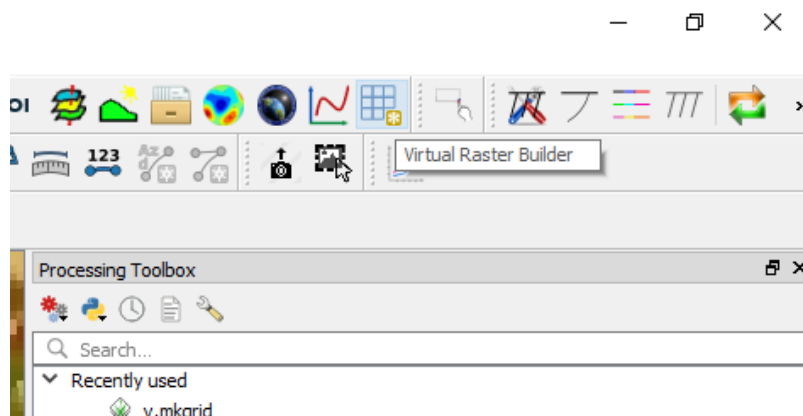


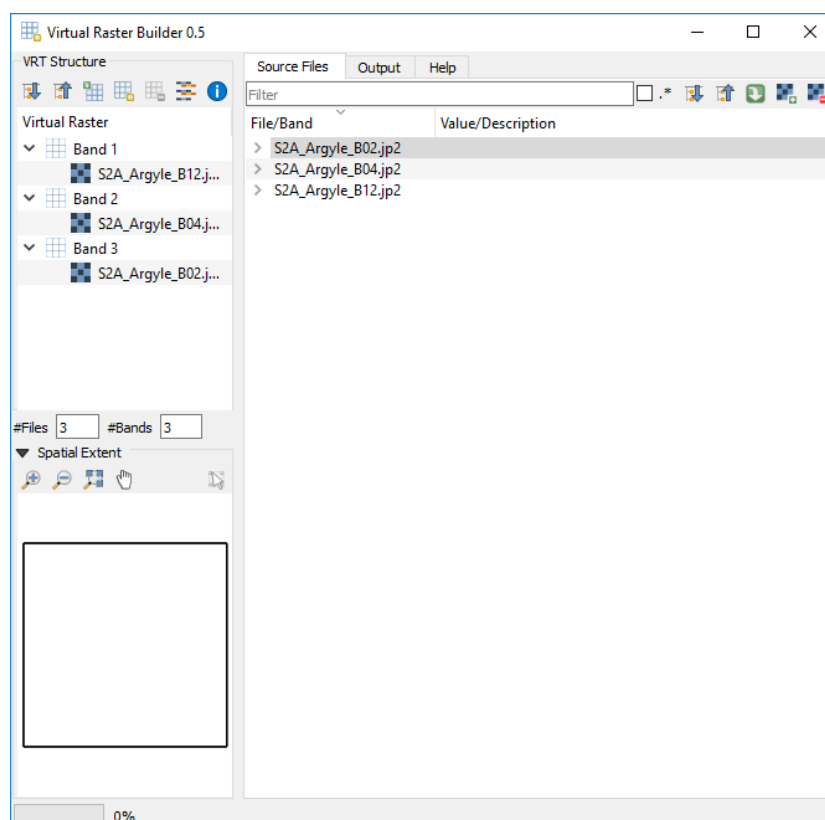
To adjust the colour stretch, zoom into a part of the image where you want to see more detail and then use the Layer panel to right click on the RGB layer and select “Stretch using current extent”. This can be done multiple times until you get the desired result (see below for example). Alternatively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



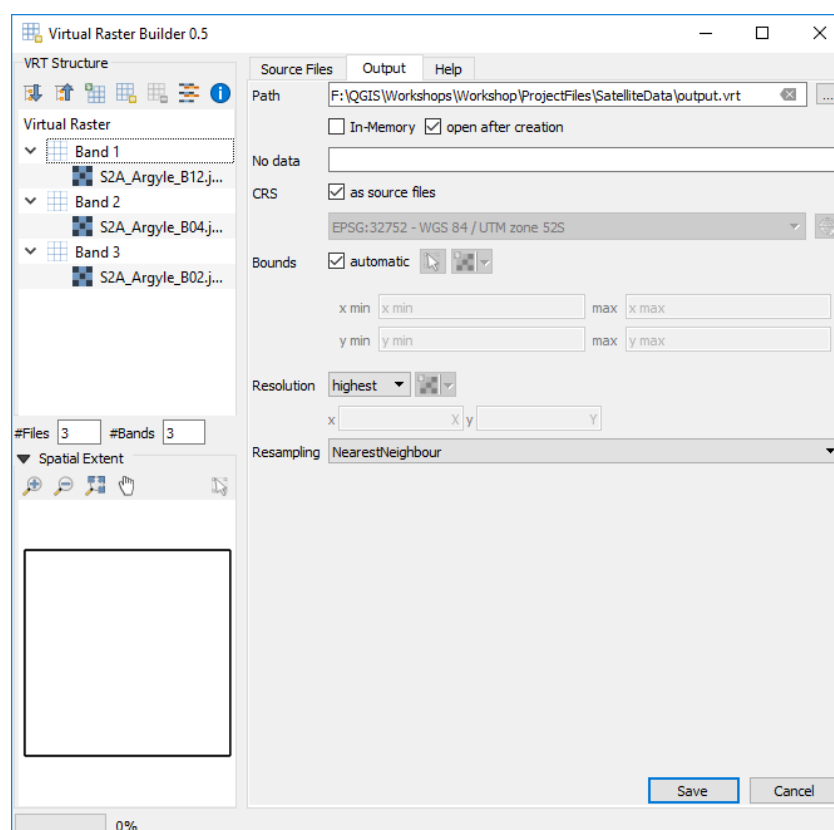
The “Virtual” RGB image is currently only a temporary file. To create a permanent image, right click on the image layer in the Layers panel and select “Save As”. Select the “Rendered Image” option, click the “Browse” and select the folder and required file name. Change the coordinate system if required. 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 other option for producing the RGB image is by using the “Virtual Raster Builder” plugin.





Add the files via the “Source Files” tab and these can be renamed in the left hand side window for reference purposes, e.g. Band1 can be renamed to Band12. The RGB creation is done via the “Output” tab and this creates a temporary virtual file.





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

Save Raster Layer as...

Output mode: ☐ Raw data ☒ Rendered image

Format: **GeoTIFF** ☐ Create VRT

Save as: **GIS\Workshops\Workshop08_v3\ProjectFiles\SatelliteData\Sentinel\SA2_Argyle_12-4-2.tif**

CRS: **EPSG:28352 - GDA94 / MGA zone 52**

☒ Add saved file to map

Extent (current: layer)

North: **8200000.0001**
 West: **399960.0000** East: **509760.0000**
 South: **8090200.0001**

Buttons: Current layer extent, Calculate from layer, Map view extent

Resolution (current: layer)

☒ Horizontal: **10** Vertical: **10** **Layer resolution**
☐ Columns: **10980** Rows: **10980** **Layer size**

☐ **Create Options**

Profile: **Default**

Name	Value

Buttons: OK, Cancel, Help

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, use 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 (<http://www.saga-gis.org/en/index.html>). This a powerful and free GIS analysis program and has a good help file (<https://sourceforge.net/projects/saga-gis/files/SAGA%20-%20Documentation/SAGA%20%20User%20Guide/>). The mosaicking option is found in the

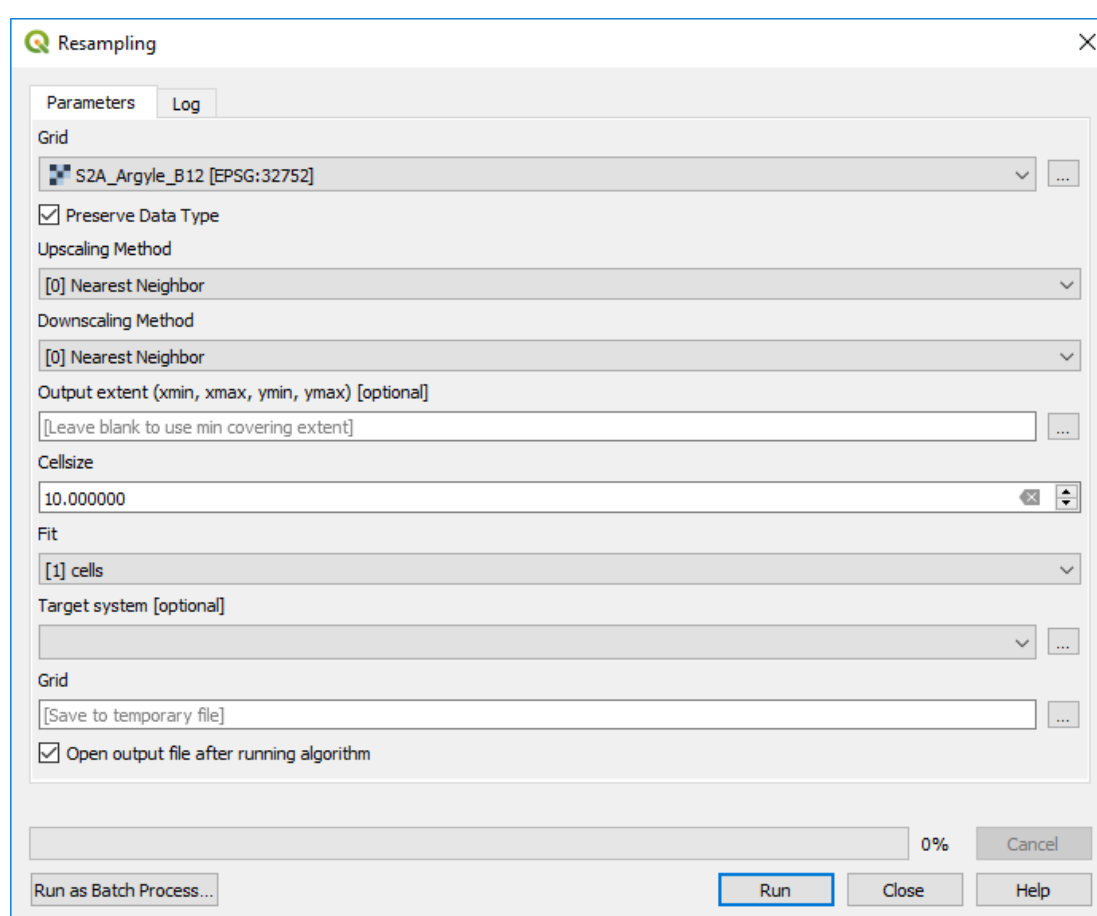


Geoprocessing > Grid > Grid System > Mosaicking menu item. Use the Match option “match histograms of overlapping area”.

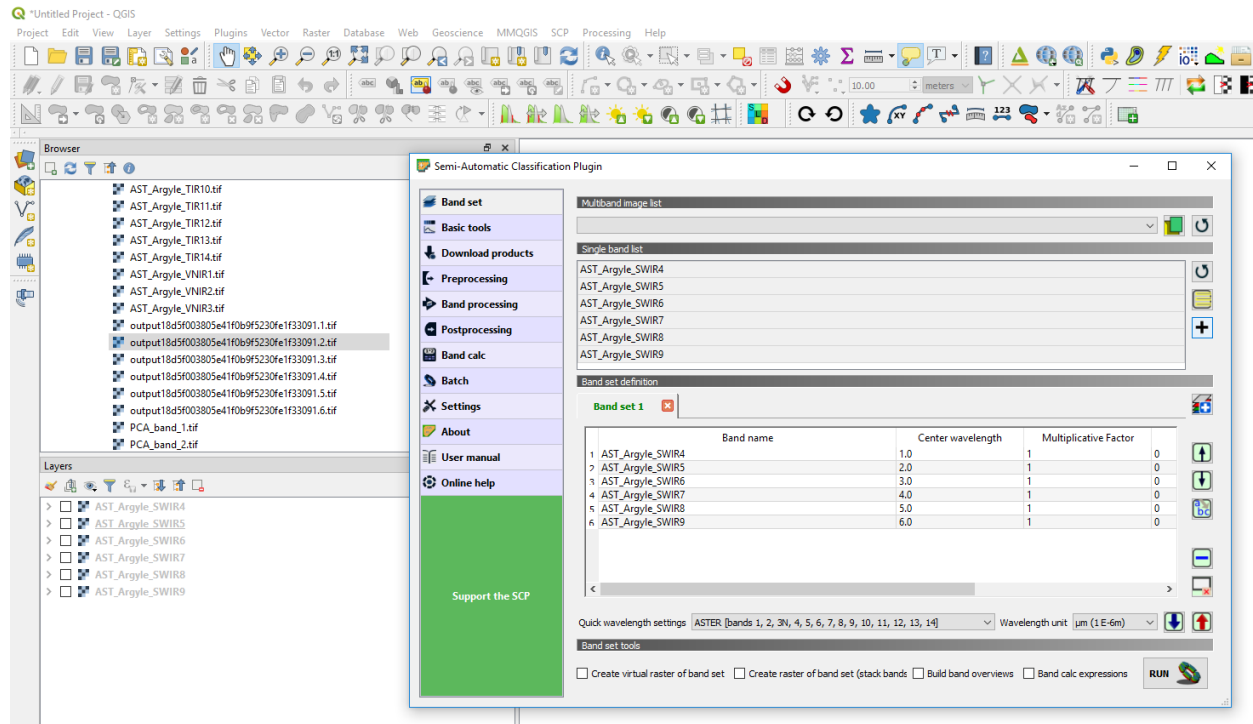
11.6 Principal Components Analysis (PCA)

Principal Components Analysis (PCA) can be undertaken using the Semi-Automatic Classification plugin. 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).

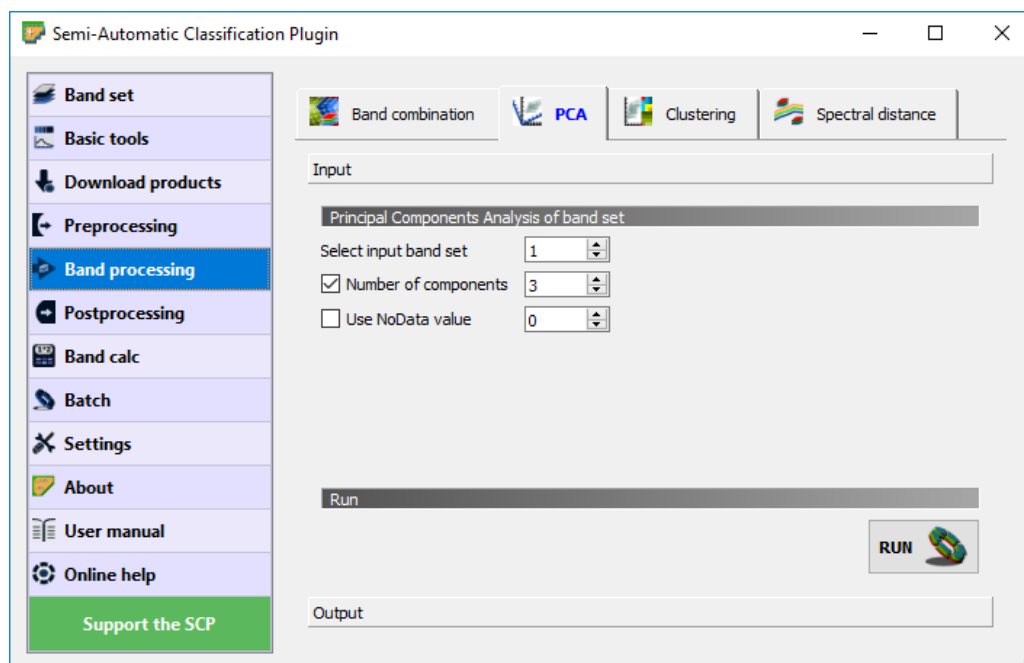
If you need to resample the raster to a different cell/pixel size, ensure you check the Cellsize and “Fit” to cell, otherwise it will offset the resulting image.



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).



12: MAP PRODUCTION

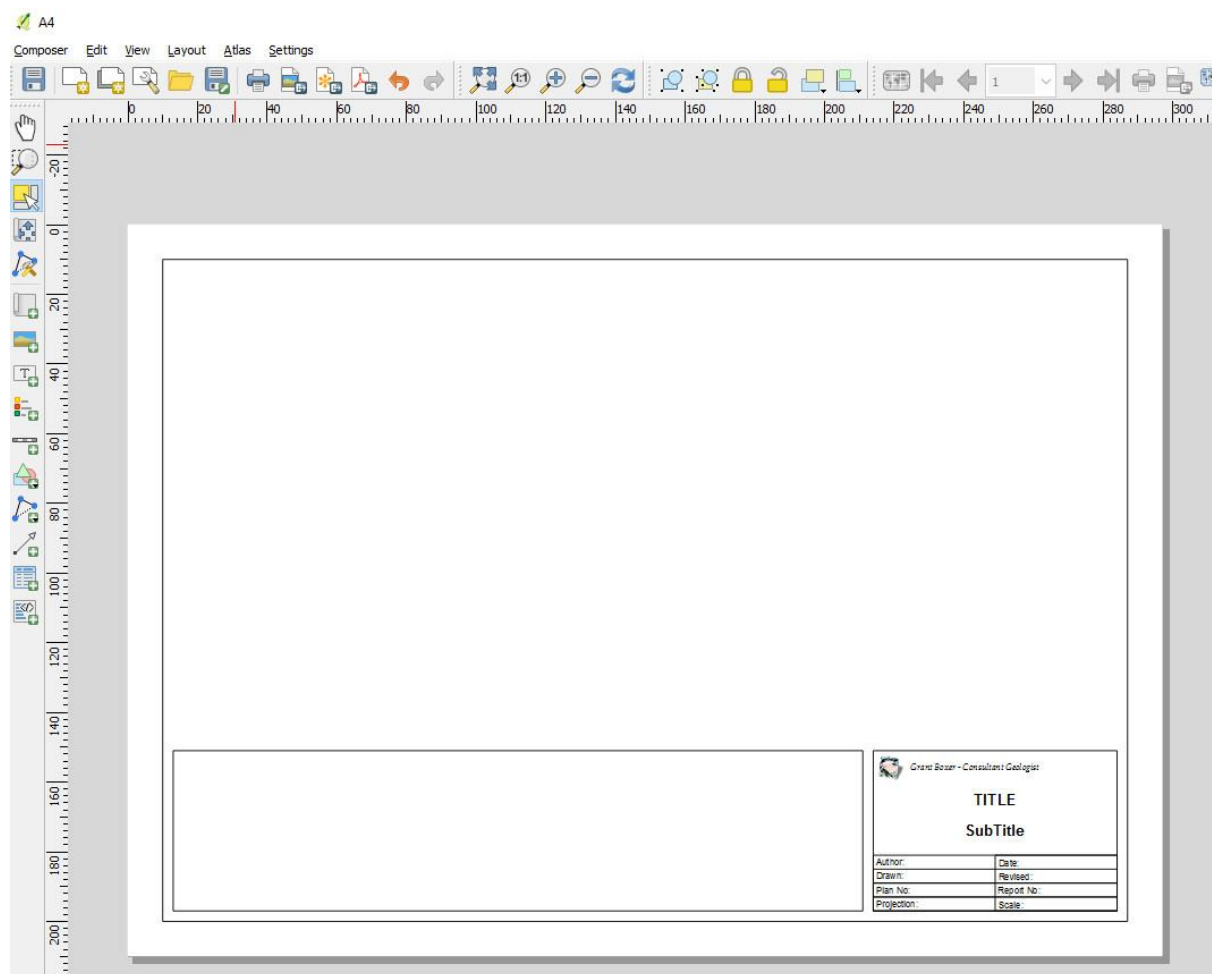
12.1 Print Layout

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. Map creation is described in Hands-On Workshop 1. 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.

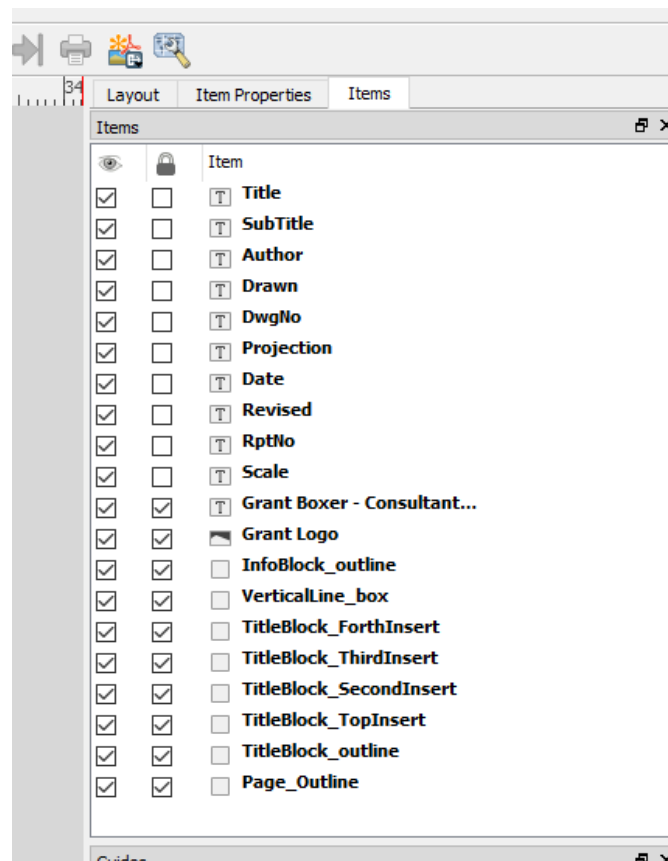
12.2 Map Templates

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.

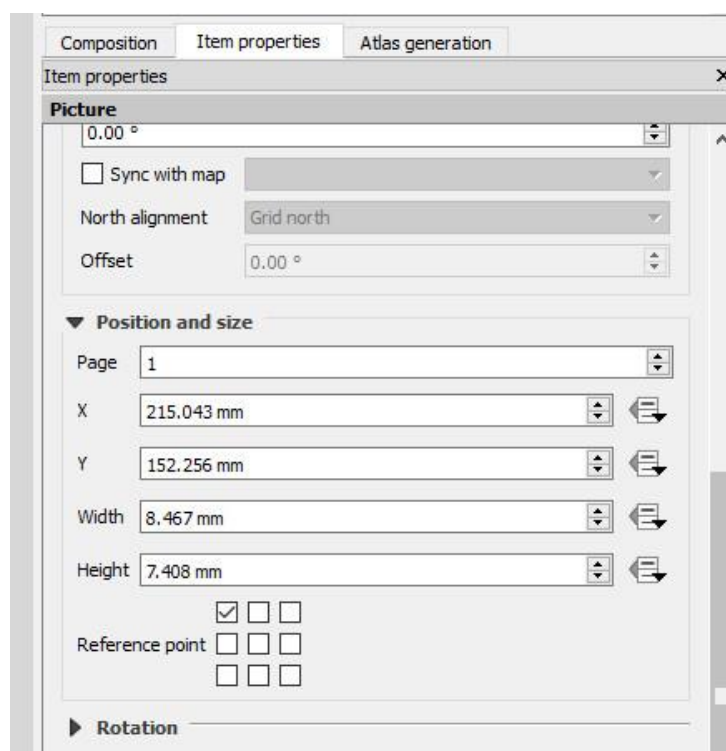




Each item of the template is listed in the Item panel and can be turned on or off and edited. Note that the position of the features can be set and adjusted using the “Position and Size” options in the item properties dialog box. Each item, e.g. page frame, insert box, logo, etc., has its own item properties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

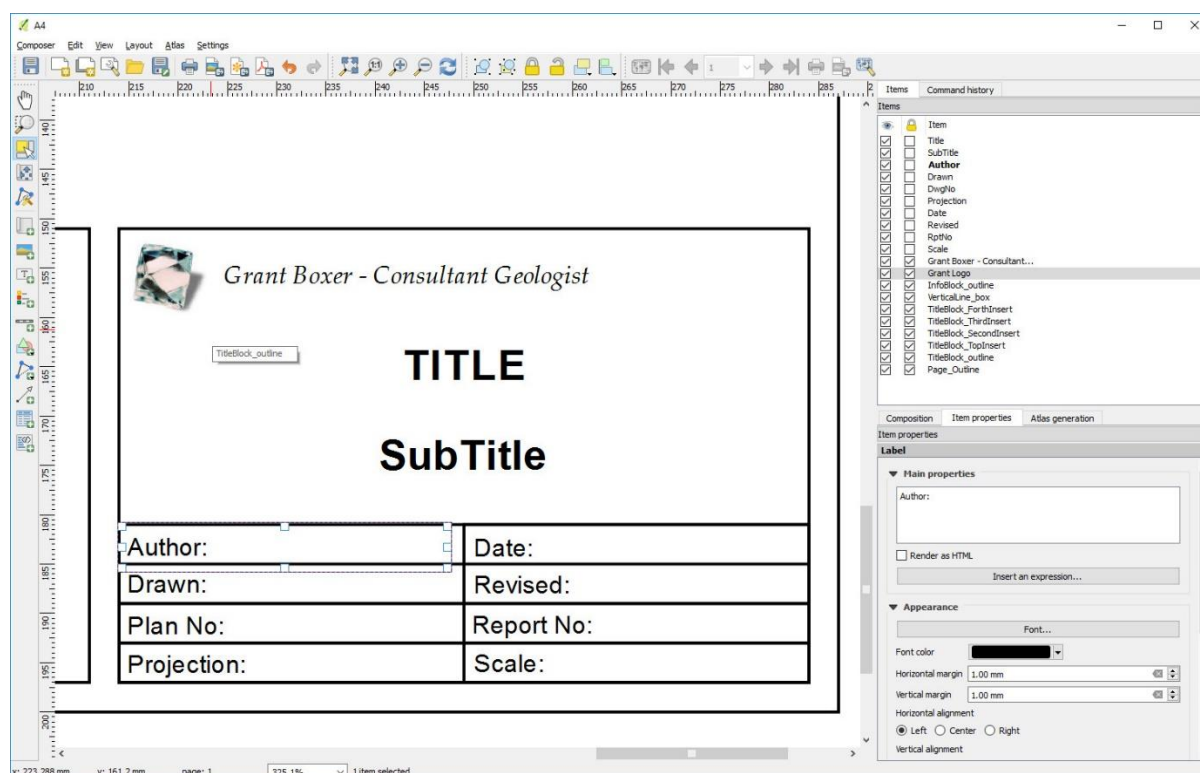


The image above shows all the items that map up the map frame.



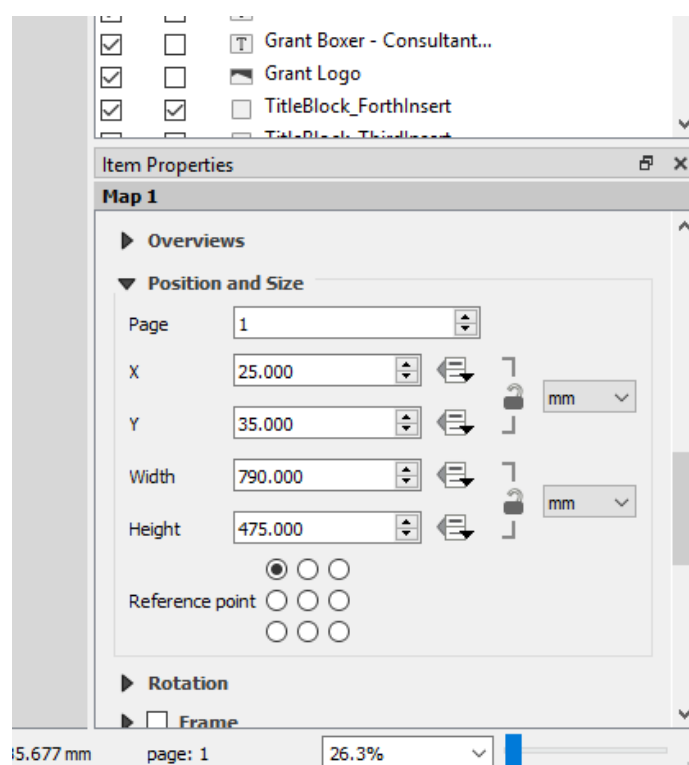
The example above is the “Logo” item (diamond image on the layout) and its location is referenced to the top left-hand corner of the page as shown in the 3 x 3 box array. It is located 215 mm to the right and 152 mm below the top left hand corner of the page, with a width of 8 mm and a height of 7 mm.

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”.

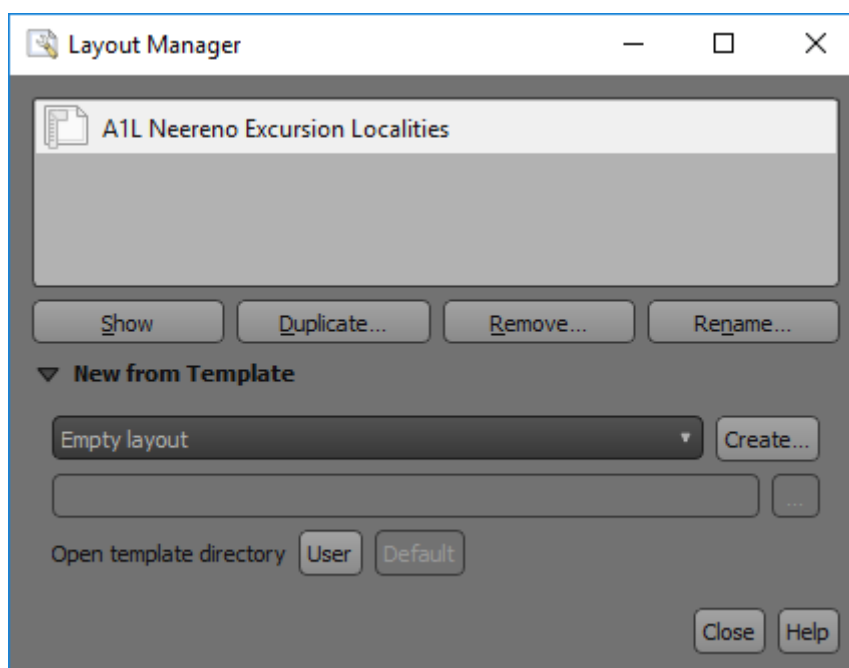
The position and size of the inserted map window can be adjusted under the “Map” item properties and using the “Position and Size” options. The reference point in the figure below shows the measurements from the top LHS of the page.





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.



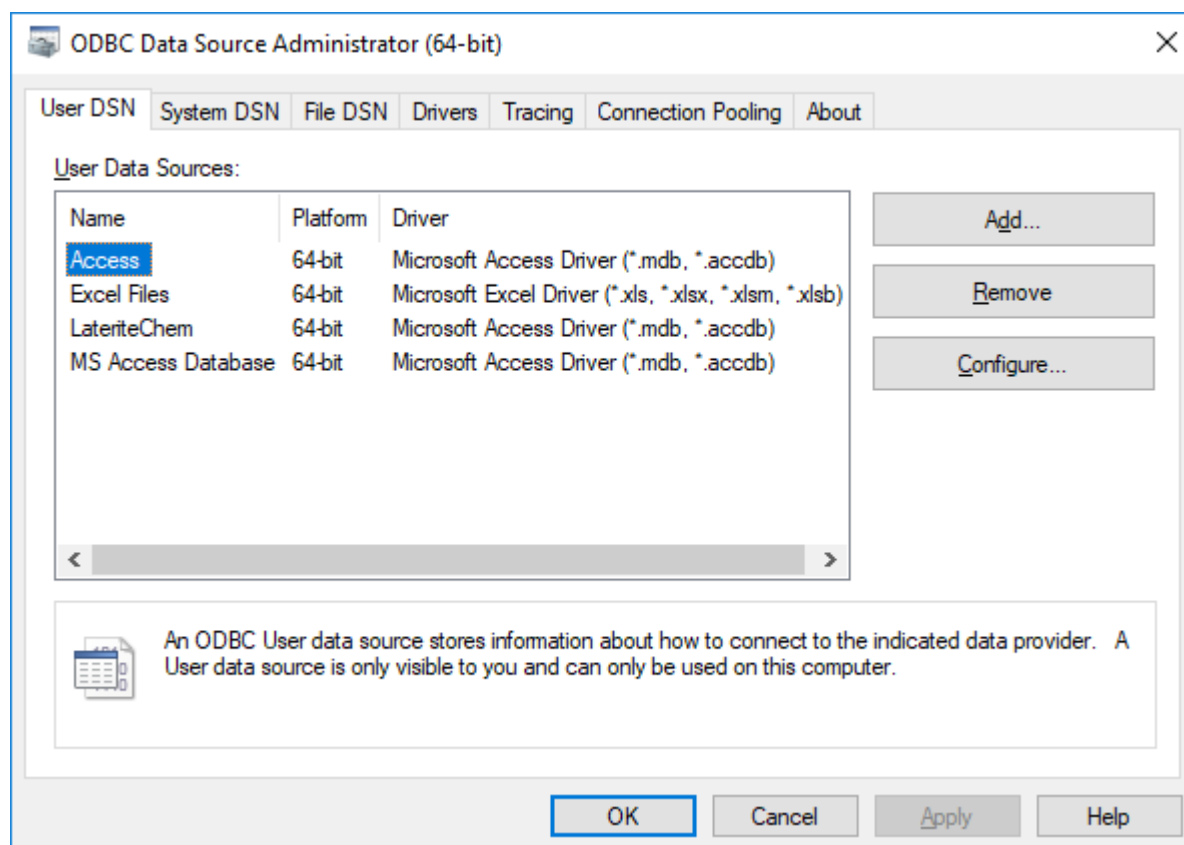


13: MISCELLANEOUS TRICKS AND TIPS

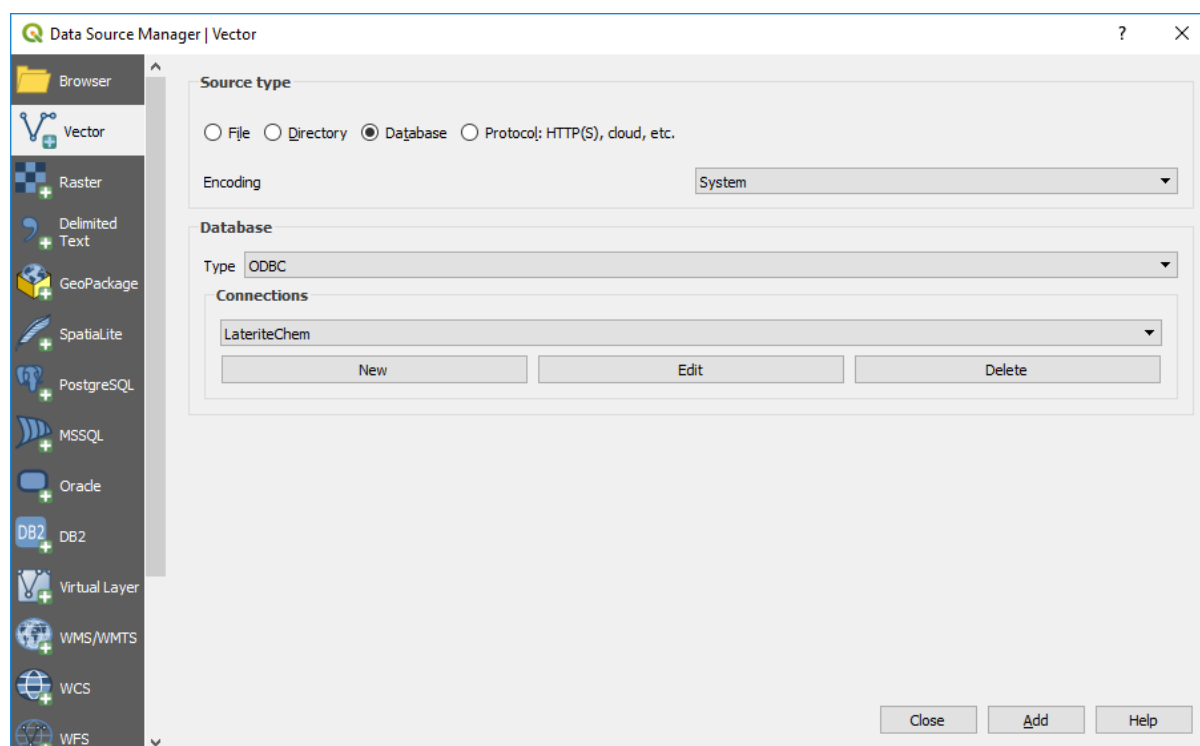
Access Databases

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

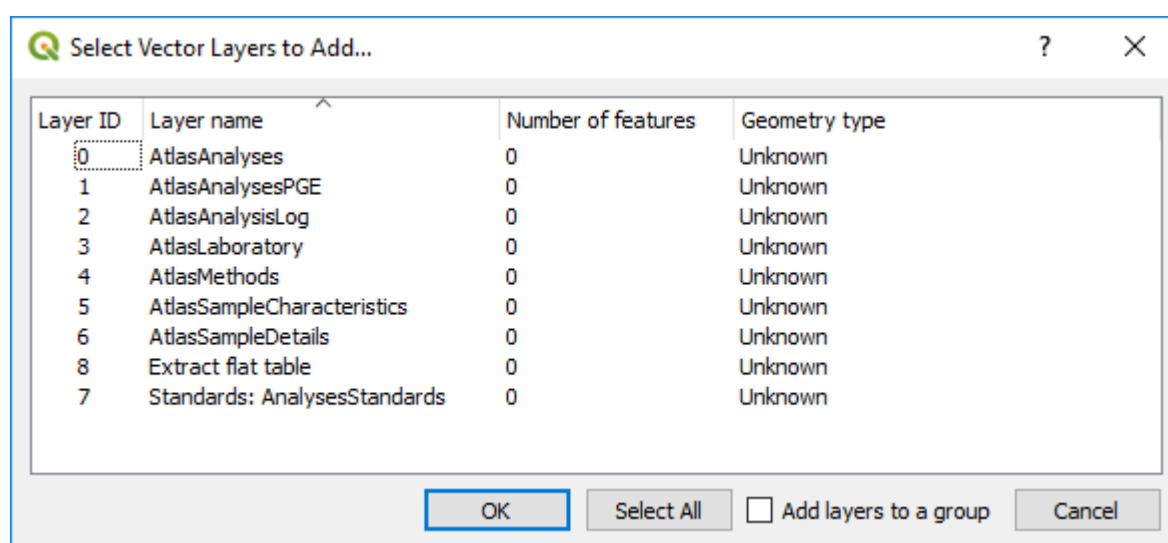
Open the 64-bit ODBC admin window (via the Windows search box) and add the Access database name and location in the User DSN tab – e.g. “LateriteChem”.



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.



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.

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.



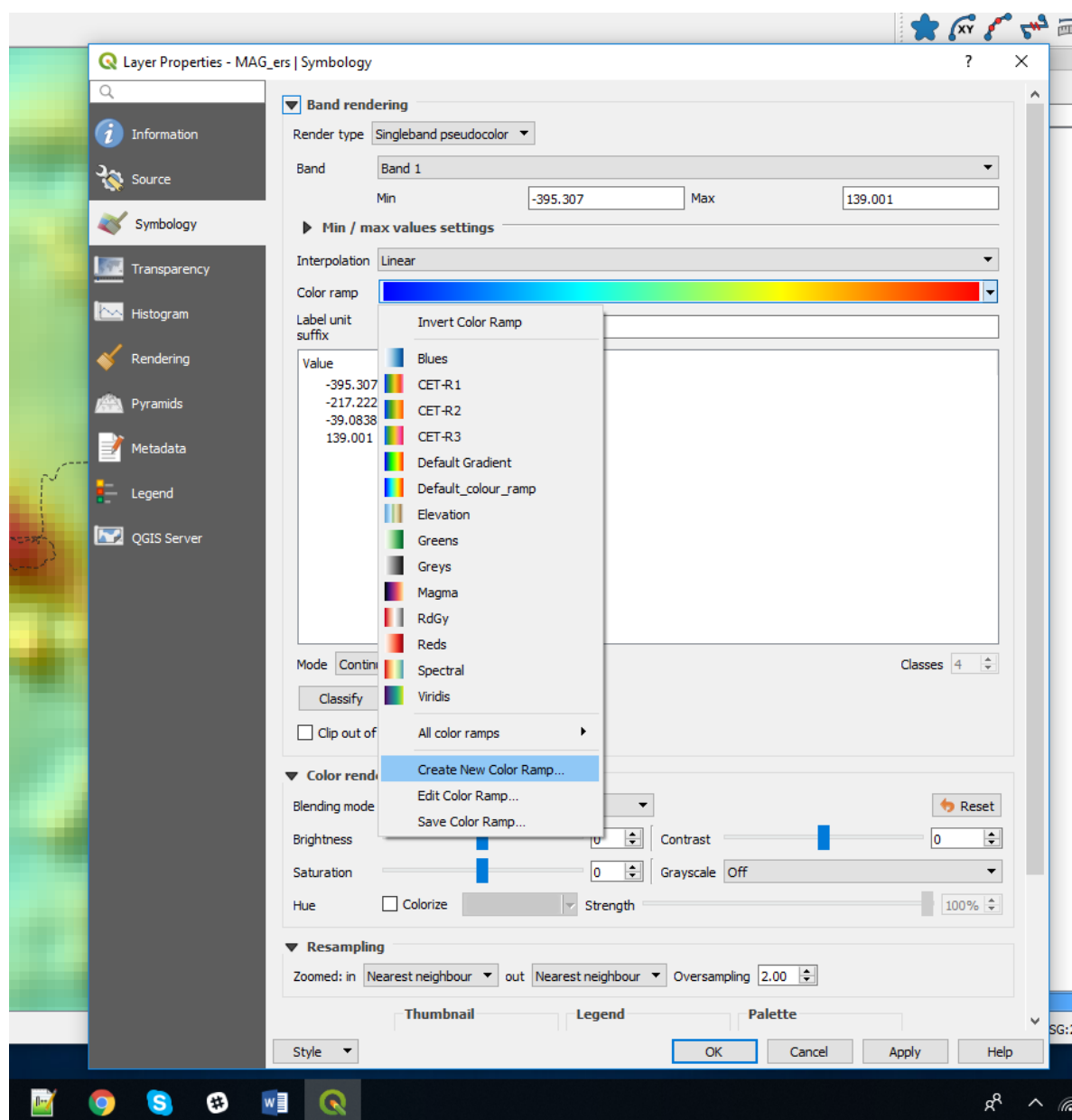
Bookmarks

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.

Colour Ramps

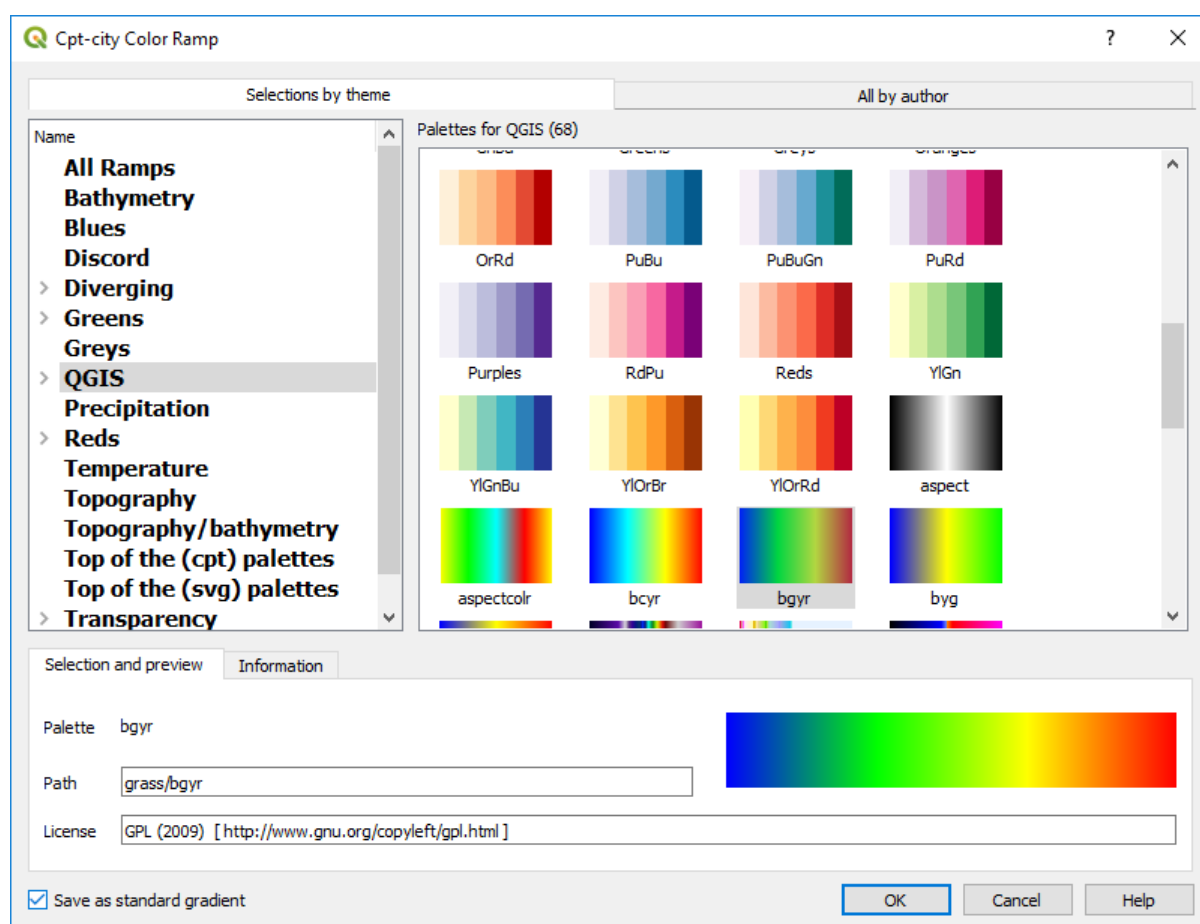
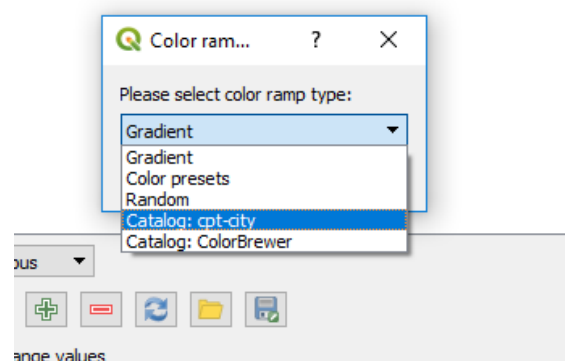
To add additional colour ramps to the default option use the “Create New Colour Ramp” from the drop down box to the right of the Color Ramp selection box,. The preset colour ramps are shown in the “Color Ramp” dialog box and I recommend the Catalog: cpt-city option which will display the next dialog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

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





436 -217
54... -39.1
139

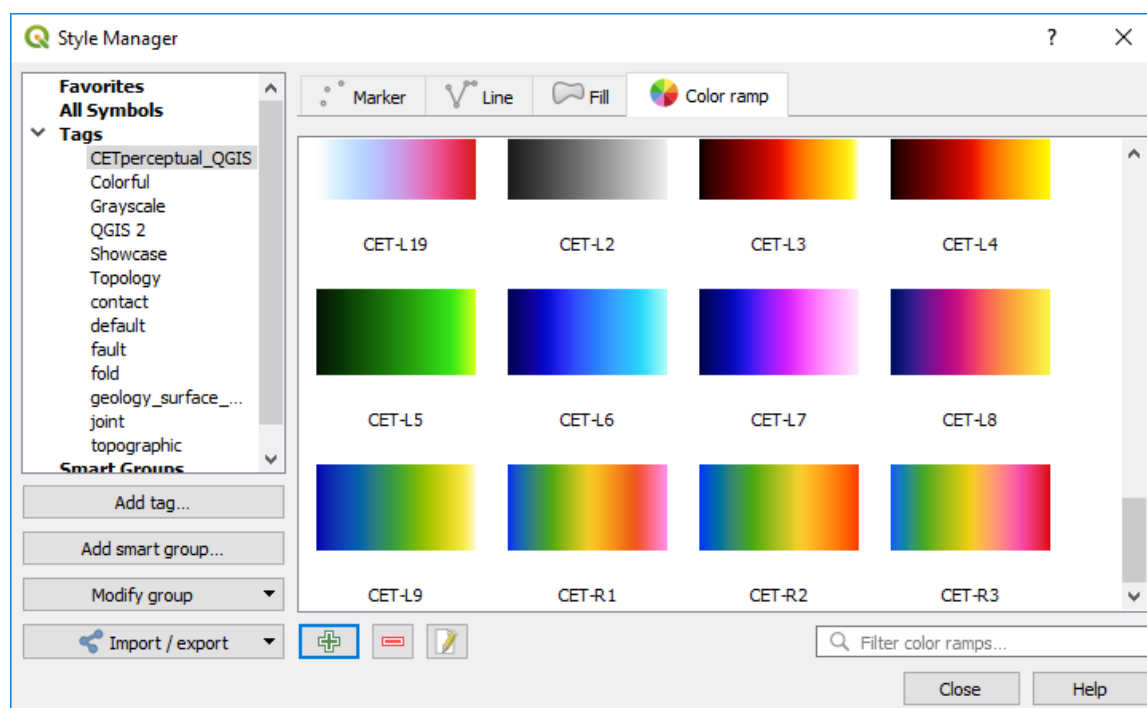


New colour ramps can also be imported via the Style Manager dialog box.

The Centre for Exploration Targeting (CET) in Perth have developed colour ramps that are better for visual perception (see this link <https://peterkovesi.com/projects/colourmaps/>). They are



available in a QGIS xml format that can be imported via the Style Manager. These styles can then be access as favourites. My preference for data grids such as magnetics is to use the CET-R1 colour ramp.



Colour Selection

To assist in selecting colours for maps, you can visit the ColorBrewer website (<http://colorbrewer2.org>) where rgb, hex and cymk values of a huge variety of colour options can be viewed and selected as required.

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.

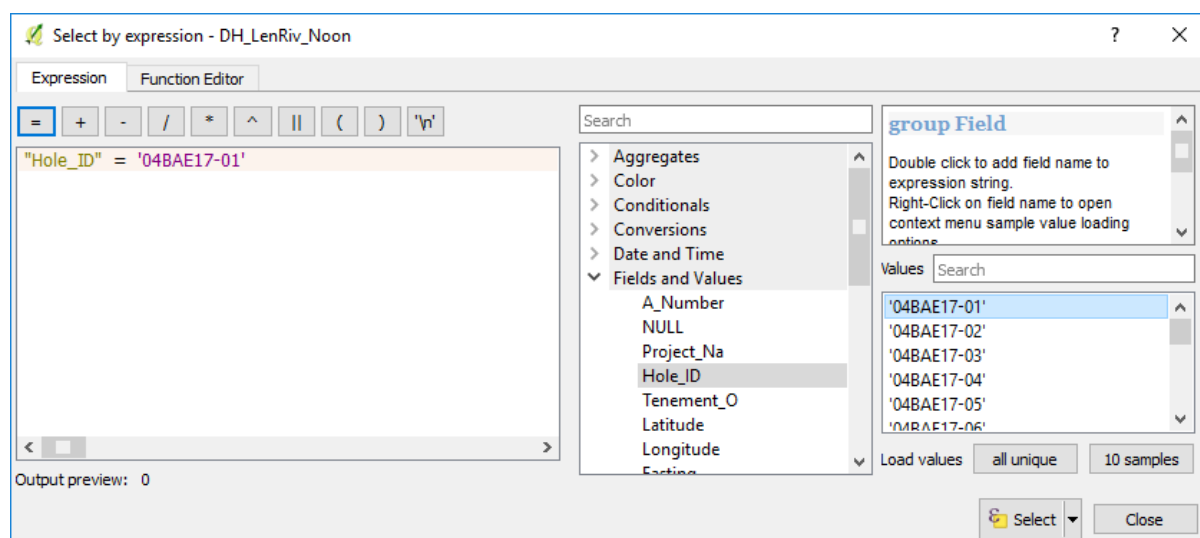
Highlight the layer in the Layers panel, bring up its attribute table and click on the “Select Features Using an Expression” button.

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...	678987.00000000...	8067511.000000...	51.000000000000...		AC	21
2	59481.00000000...	DVDH803	-17.4726948067...	124.6856087811...	678987.00000000...	8067361.000000...	51.000000000000...		AC	21
3	59481.00000000...	BLDH3055	-17.4798308999...	124.6858815523...	679009.00000000...	8066571.000000...	51.000000000000...		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	-17.4445249038...	124.9697496225...	709200.00000000...	8070190.000000...	51.000000000000...		LD	12
2	59481.00000000...	DVDH800	-17.4713395183...	124.6855963214...	678987.00000000...	8067511.000000...	51.000000000000...		AC	21
3	59481.00000000...	DVDH803	-17.4726948067...	124.6856087811...	678987.00000000...	8067361.000000...	51.000000000000...		AC	21
4	59481.00000000...	BLDH3055	-17.4798308999...	124.6858815523...	679009.00000000...	8066571.000000...	51.000000000000...		AC	21
5	59481.00000000...	BLDH3056	-17.4800567811...	124.6858836303...	679009.00000000...	8066546.000000...	51.000000000000...		AC	21

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	-17.4445249038...	124.9697496225...	709200.00000000...	8070190.000000...	51.000000000000...		LD	12
2	59481.00000000...	DVDH800	-17.4713395183...	124.6855963214...	678987.00000000...	8067511.000000...	51.000000000000...		AC	21
3	59481.00000000...	DVDH803	-17.4726948067...	124.6856087811...	678987.00000000...	8067361.000000...	51.000000000000...		AC	21
4	59481.00000000...	BLDH3055	-17.4798308999...	124.6858815523...	679009.00000000...	8066571.000000...	51.000000000000...		AC	21
5	59481.00000000...	BLDH3056	-17.4800567811...	124.6858836303...	679009.00000000...	8066546.000000...	51.000000000000...		AC	21



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/redone capabilities.

Description of the tools

Split multi part 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.

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.

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.

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.



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).

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.

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.

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.

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.

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.



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.

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:

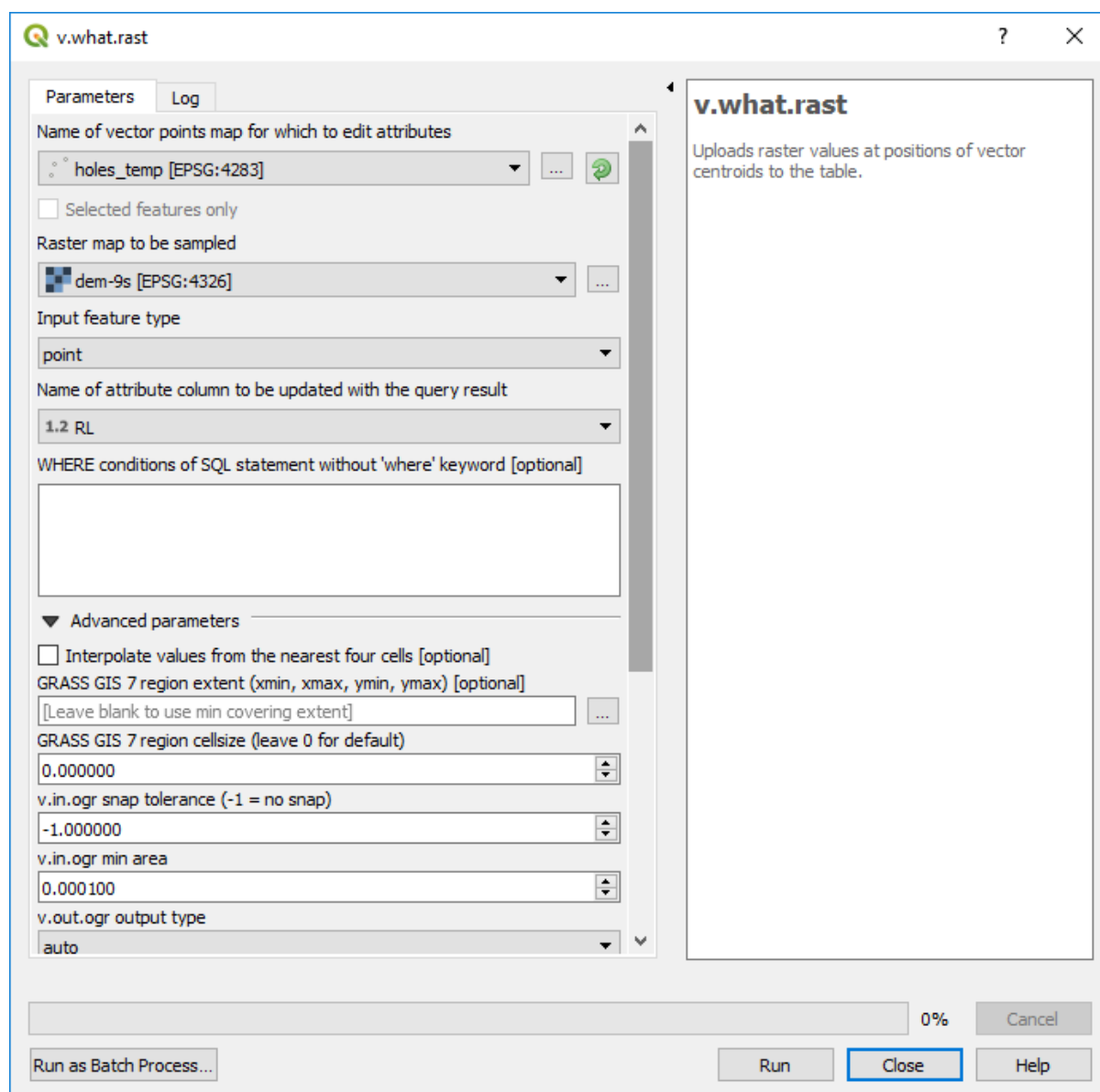
1. batch mode: all selected lines are flipped.
2. interactive mode: click any line feature to have it flipped (successful clicking depends on layer's snap settings).

Favourites

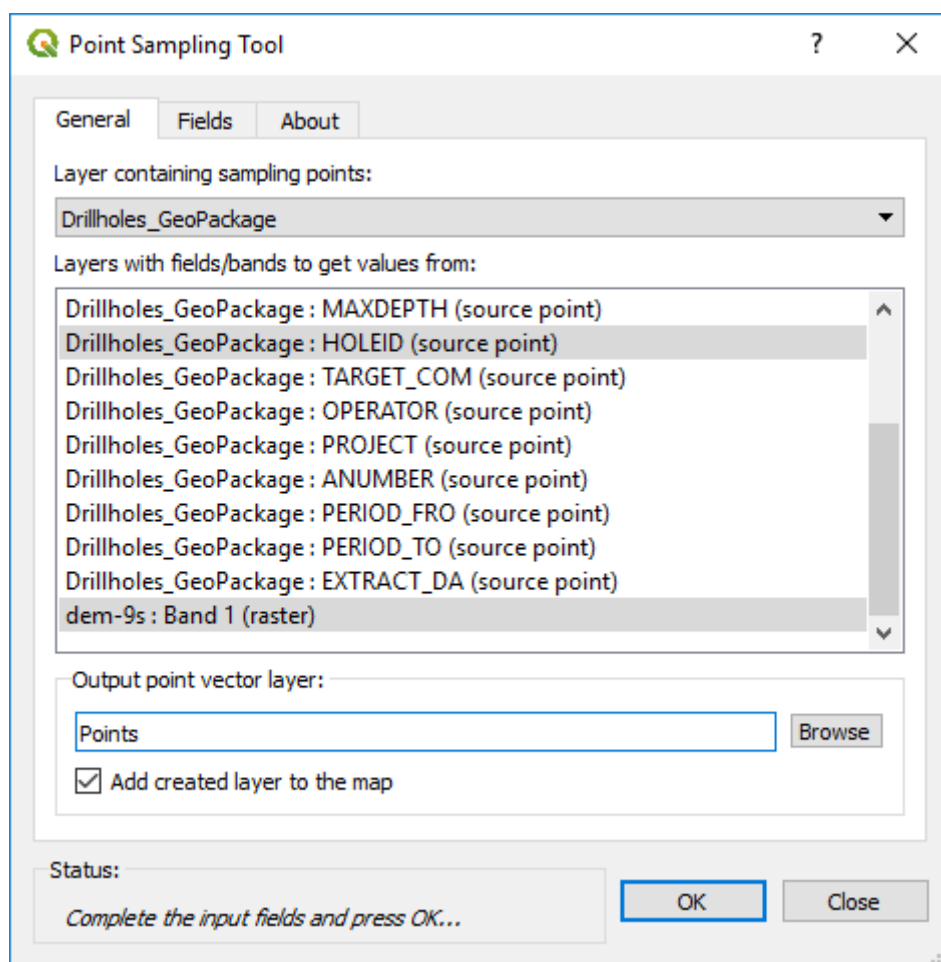
To add a directory as a Favourite for quick access, right click on the "Favourites" item in the Browser panel, then add directory. The favourite directory will then make it much quicker to access commonly used files.

Point Sampling of Raster Data

The quickest method to populate drill hole RL's for example, is to use the "v.what.rast" algorithm. This algorithm can update fields in an existing table.



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 undated the data field.

Profile Tool

This plug-in allows the user to put a line across a grid and obtain a profile along the line.

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.

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.



Quick Rectangles, Circles, Ellipse Shapes

The Shape Digitising tool bar allow the creation of vector shapes, e.g. rectangle and circles.

Refractor Field

The Refractor Field algorithm allow the modification of a tables' attributes. Be careful using this!

	Point	Datum	Zone	Easting	Northing	RL	ObsType	STRK_PLUNG	Dip	Comment
1	GB02	GDA94	50	397480.0000000...	6741475.000000...	318.0000000000...				Pisolitic laterit
2	GB03	GDA94	50	397560.0000000...	6741440.000000...	313.0000000000...	Bedding	45.0000000000...	35.0000000000...	Outcrop of la
3	GB04	GDA94	50	397583.0000000...	6741378.000000...	309.0000000000...	Joint	335.0000000000...	75.0000000000...	Breccia, vein
4	GB04	GDA94	50	397583.0000000...	6741378.000000...	309.0000000000...				
5	GB05	GDA94	50	397643.0000000...	6741345.000000...	305.0000000000...	FoldAxis	25.0000000000...	45.0000000000...	Breccia, small
6	GB05	GDA94	50	397643.0000000...	6741345.000000...	305.0000000000...				
7	GB06	GDA94	50	397470.0000000...	6741470.000000...	318.0000000000...	Bedding	50.0000000000...	35.0000000000...	Top of pisolite
8	GB07	GDA94	50	398085.0000000...	6741780.000000...	307.0000000000...	Bedding	65.0000000000...	35.0000000000...	Breccia with g
9	GB08	GDA94	50	398037.0000000...	6741806.000000...	307.0000000000...	Bedding	75.0000000000...	35.0000000000...	Granitic clasts
10	GB08	GDA94	50	398037.0000000...	6741806.000000...	307.0000000000...				
11	GB09	GDA94	50	398040.0000000...	6741845.000000...	307.0000000000...	Bedding	90.0000000000...	35.0000000000...	Megabreccia
12	GB09	GDA94	50	398040.0000000...	6741845.000000...	307.0000000000...				
13	GB09	GDA94	50	398040.0000000...	6741845.000000...	307.0000000000...				

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

	Source expression	Field name	Type	Length	Precision
2	abc Zone	Zone	String	254	0
3	1.2 Easting	Easting	Double	23	2
4	1.2 Northing	Northing	Double	23	2
5	1.2 RL	RL	Double	23	2
6	abc ObsType	ObsType	String	254	0
7	1.2 STRK_PLUNG	STRK_PLUNG	Double	23	1
8	1.2 Dip	Dip	Double	23	1

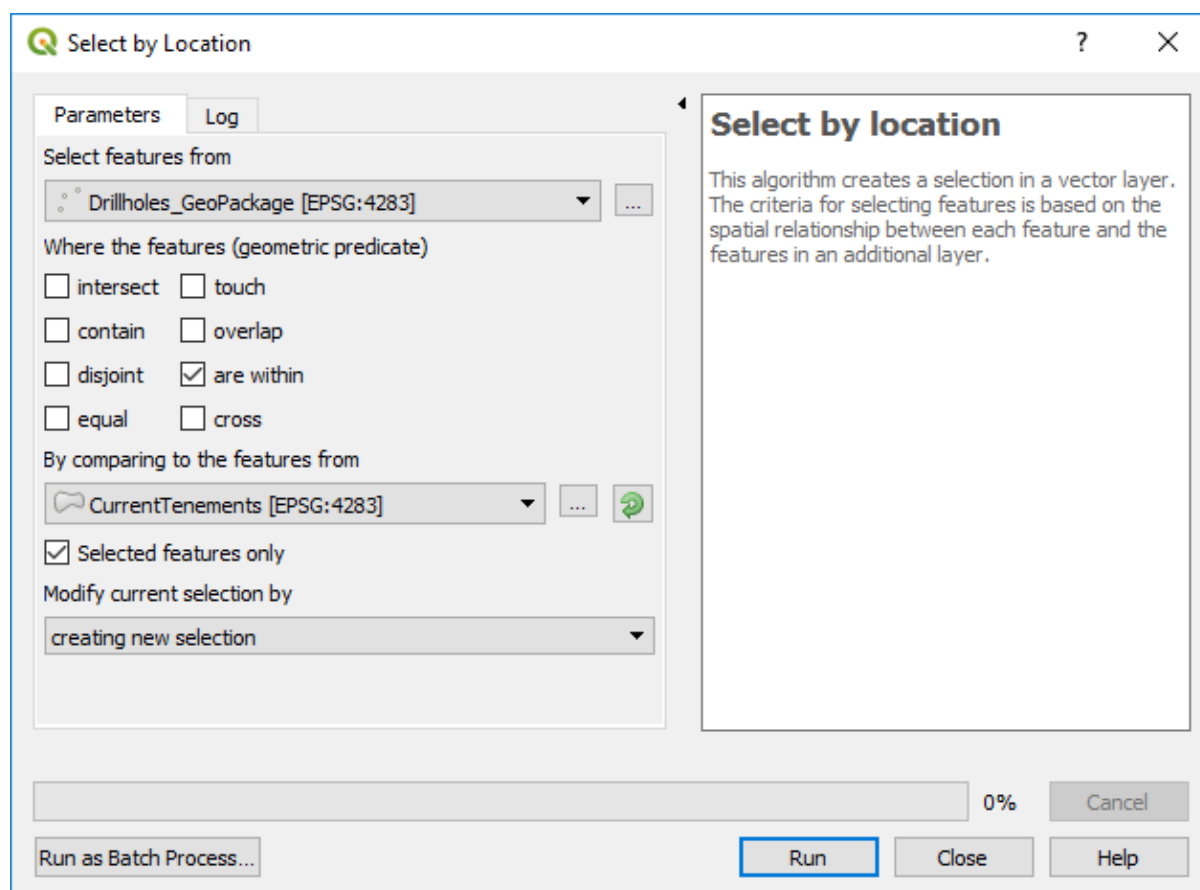
Field names, types and other info can be changed in this window.



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 be 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 in 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!).

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.

14: REFERENCES

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APPENDIX

Lithologic Patterns for Geological Maps



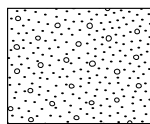


USGS
(FGDC STD-013-2006)

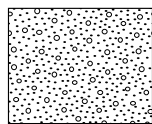


37—LITHOLOGIC PATTERNS

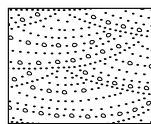
[Lithologic patterns are usually reserved for use on stratigraphic columns, sections, or charts]

37.1—Sedimentary-rock lithologic patterns

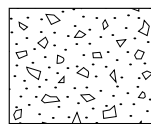
601
Gravel or
conglomerate
(1st option)



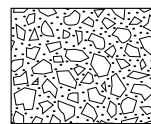
602
Gravel or
conglomerate
(2nd option)



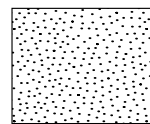
603
Crossbedded gravel
or conglomerate



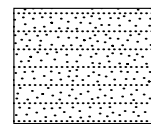
605
Breccia (1st option)



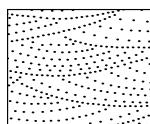
606
Breccia (2nd option)



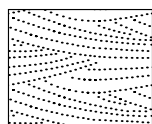
607
Massive sand or
sandstone



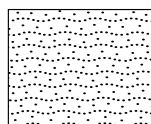
608
Bedded sand or
sandstone



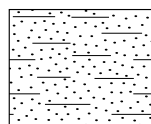
609
Crossbedded sand
or sandstone
(1st option)



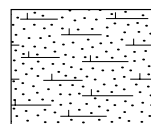
610
Crossbedded sand
or sandstone
(2nd option)



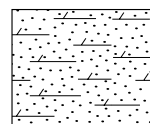
611
Ripple-bedded sand
or sandstone



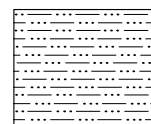
612
Argillaceous or
shaly sandstone



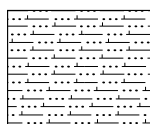
613
Calcareous
sandstone



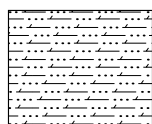
614
Dolomitic
sandstone



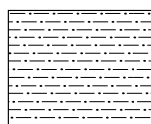
616
Silt, siltstone,
or shaly silt



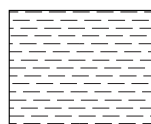
617
Calcareous
siltstone



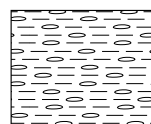
618
Dolomitic
siltstone



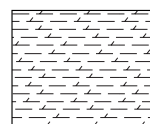
619
Sandy or silty
shale



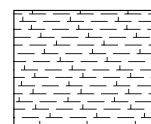
620
Clay or clay
shale



621
Cherty shale



622
Dolomitic shale



623
Calcareous shale
or marl



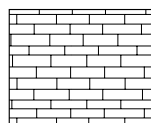
624
Carbonaceous
shale



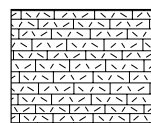
625
Oil shale



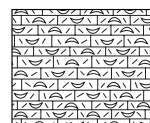
626
Chalk



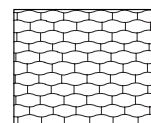
627
Limestone



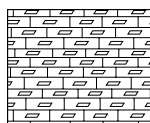
628
Clastic
limestone



629
Fossiliferous clastic
limestone



630
Nodular or irregularly
bedded limestone



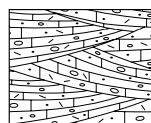
631
Limestone, irregular
(burrow?) fillings of
saccharoidal dolomite



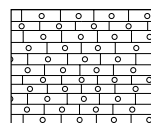
632
Crossbedded
limestone



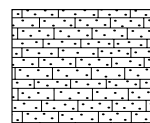
633
Cherty crossbedded
limestone



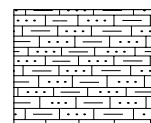
634
Cherty and sandy
crossbedded
clastic limestone



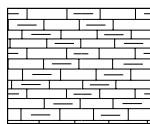
635
Oolitic
limestone



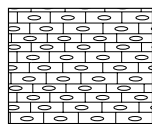
636
Sandy limestone



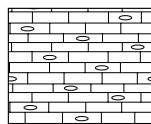
637
Silty limestone



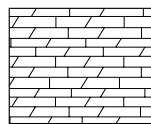
638
Argillaceous or
shaly limestone



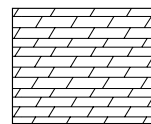
639
Cherty limestone
(1st option)



640
Cherty limestone
(2nd option)



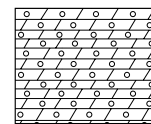
641
Dolomitic limestone,
limy dolomite, or
limy dolomite



642
Dolostone or
dolomite



643
Crossbedded
dolostone or
dolomite

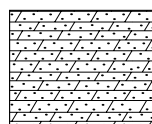


644
Oolitic dolostone
or dolomite

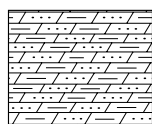
*For more information, see general guidelines on pages A-i to A-v.

37—LITHOLOGIC PATTERNS (continued)

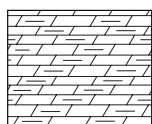
[Lithologic patterns are usually reserved for use on stratigraphic columns, sections, or charts]

37.1—Sedimentary-rock lithologic patterns (continued)

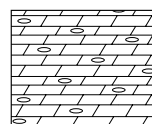
645
Sandy dolomite
or dolomite



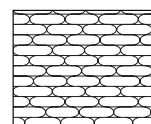
646
Silty dolomite
or dolomite



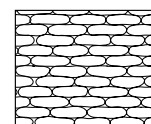
647
Argillaceous or
shaly dolomite
or dolomite



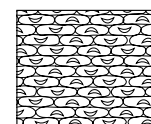
648
Cherty dolomite
or dolomite



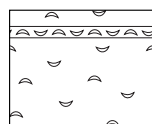
649
Bedded chert
(1st option)



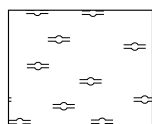
650
Bedded chert
(2nd option)



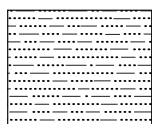
651
Fossiliferous
bedded chert



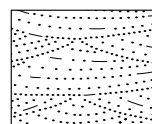
652
Fossiliferous rock



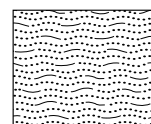
653
Diatomaceous
rock



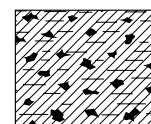
654
Subgraywacke



655
Crossbedded
subgraywacke



656
Ripple-bedded
subgraywacke



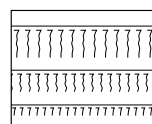
657
Peat



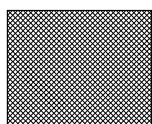
658
Coal



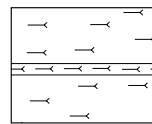
659
Bony coal or
impure coal



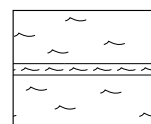
660
Underclay



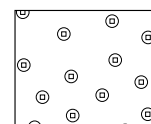
661
Flint clay



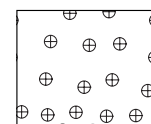
662
Bentonite



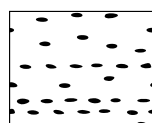
663
Glauconite



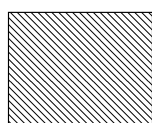
664
Limonite



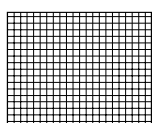
665
Siderite



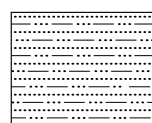
666
Phosphatic-nodular
rock



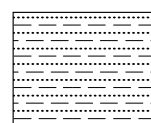
667
Gypsum



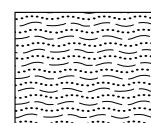
668
Salt



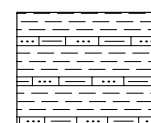
669
Interbedded
sandstone and
siltstone



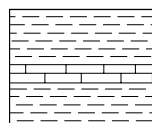
670
Interbedded
sandstone and
shale



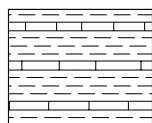
671
Interbedded ripple-
bedded sandstone
and shale



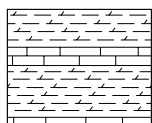
672
Interbedded shale
and silty limestone
(shale dominant)



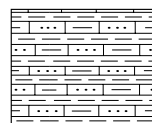
673
Interbedded shale
and limestone
(shale dominant)
(1st option)



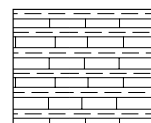
674
Interbedded shale
and limestone
(shale dominant)
(2nd option)



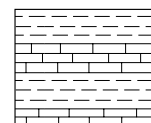
675
Interbedded calc-
areous shale and
limestone (shale
dominant)



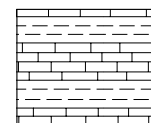
676
Interbedded
silty limestone
and shale



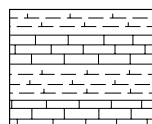
677
Interbedded
limestone and
shale (1st option)



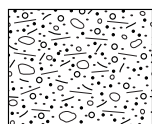
678
Interbedded
limestone and
shale (2nd option)



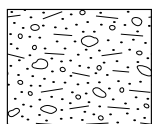
679
Interbedded
limestone and shale
(limestone dominant)



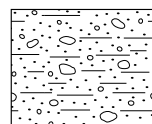
680
Interbedded
limestone and
calcareous shale



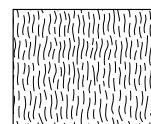
681
Till or diamicton
(1st option)



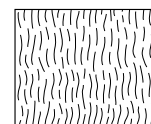
682
Till or diamicton
(2nd option)



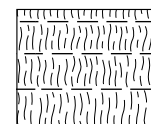
683
Till or diamicton
(3rd option)



684
Loess (1st option)



685
Loess (2nd option)



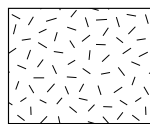
686
Loess (3rd option)

*For more information, see general guidelines on pages A-i to A-v.

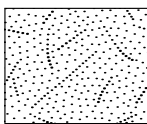
37—LITHOLOGIC PATTERNS (continued)

[Lithologic patterns are usually reserved for use on stratigraphic columns, sections, or charts]

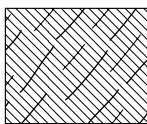
37.2—Metamorphic-rock, igneous-rock, and vein-matter lithologic patterns



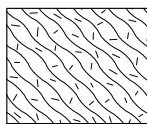
701
Metamorphism



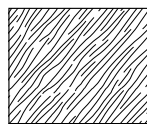
702
Quartzite



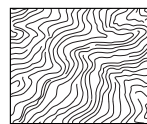
703
Slate



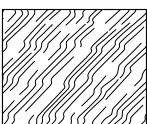
704
Schistose or
gneissoid granite



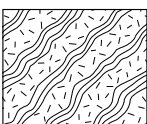
705
Schist



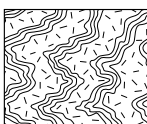
706
Contorted schist



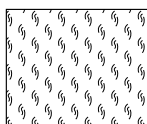
707
Schist and gneiss



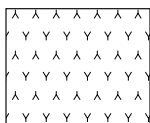
708
Gneiss



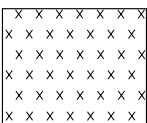
709
Contorted gneiss



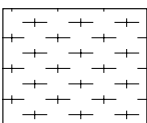
710
Soapstone, talc,
or serpentine



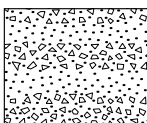
711
Tuffaceous rock



712
Crystal tuff



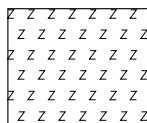
713
Devitrified
tuff



714
Volcanic breccia
and tuff



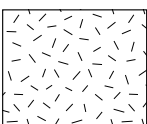
715
Volcanic breccia
or agglomerate



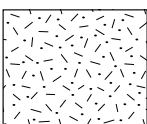
716
Zeolitic rock



717
Basaltic flows



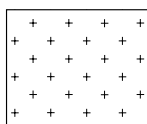
718
Granite (1st option)



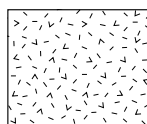
719
Granite (2nd option)



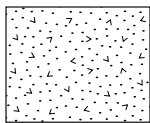
720
Banded
igneous rock



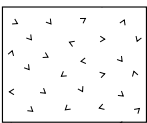
721
Igneous rock
(1st option)



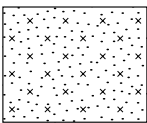
722
Igneous rock
(2nd option)



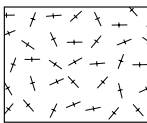
723
Igneous rock
(3rd option)



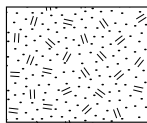
724
Igneous rock
(4th option)



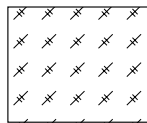
725
Igneous rock
(5th option)



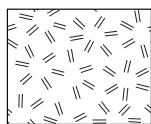
726
Igneous rock
(6th option)



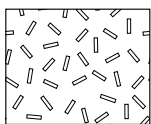
727
Igneous rock
(7th option)



728
Igneous rock
(8th option)



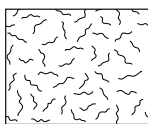
729
Porphyritic rock
(1st option)



730
Porphyritic rock
(2nd option)



731
Vitrophyre



732
Quartz



733
Ore





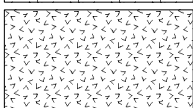
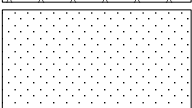
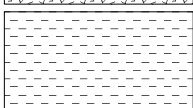
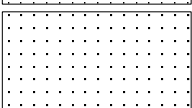

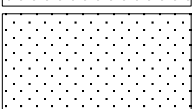
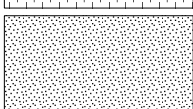
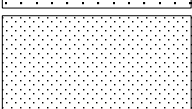
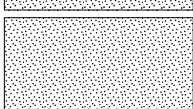
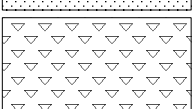
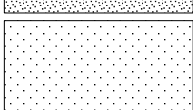
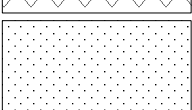
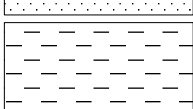
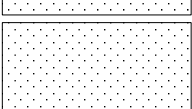
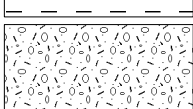


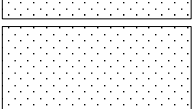

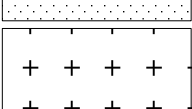
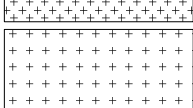
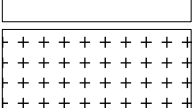
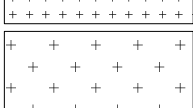
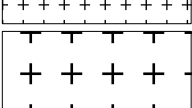
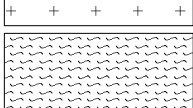
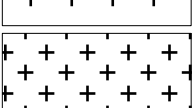
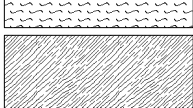
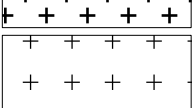


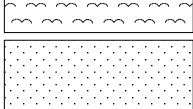
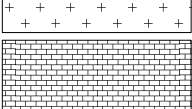
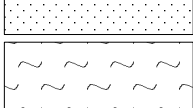
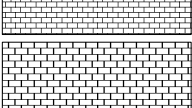
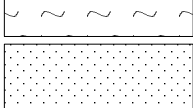
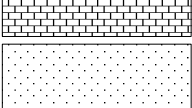
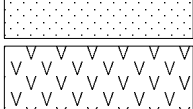
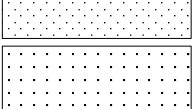
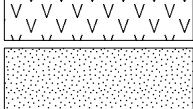
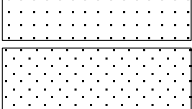
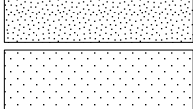
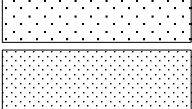
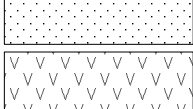
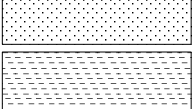
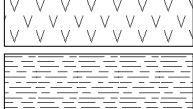
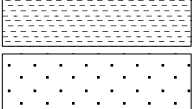
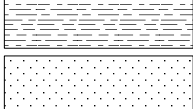
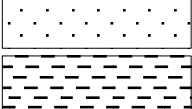
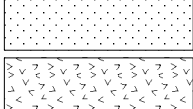
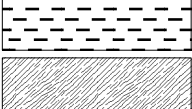
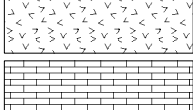
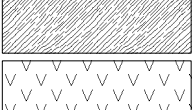
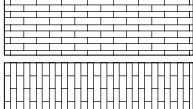
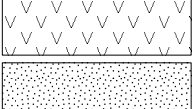
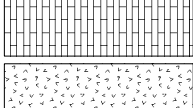
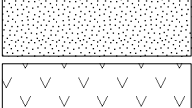
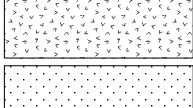
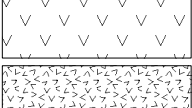
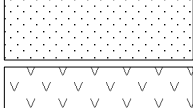
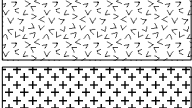
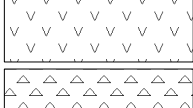
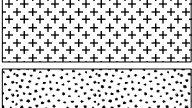

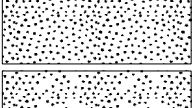
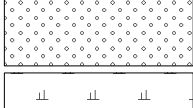
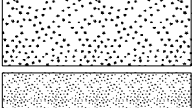
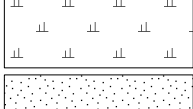
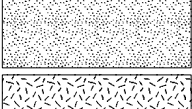
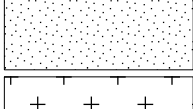
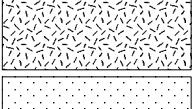
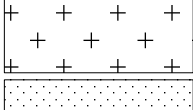
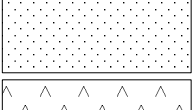
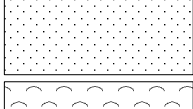
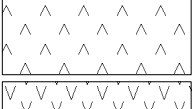
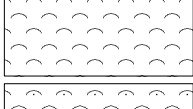
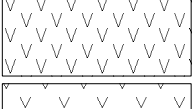
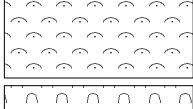

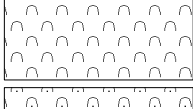
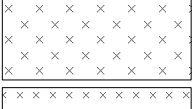
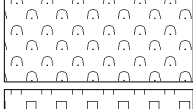
*For more information, see general guidelines on pages A-i to A-v.



Geoscience Australia



Proposed shadeset : pattern94.shd 19 Jul 95
(some patterns still to be created)

1		m16.xbm	44		m205.xbm
2		m18.xbm	45		m206.xbm
3		m19.xbm	46		m207.xbm
4		m1h.xbm	47		m208.xbm
5		m1v.xbm	48		m209.xbm
6		m22.xbm	49		m210.xbm
7		m25.xbm	50		m211.xbm
8		m26.xbm	51		m212.xbm
9		m2h.xbm	52		m213.xbm
10		m31.xbm	53		m214.xbm
11		m32.xbm	54		m215.xbm
12		m35.xbm	55		m216.xbm
13		m38.xbm	56		m217.xbm
14		m39.xbm	57		m218.xbm
15		m43.xbm	58		m219.xbm
16		m45.xbm	59		m220.xbm
17		m46.xbm	60		m221.xbm
18		m48.xbm	61		m222.xbm
19		m51.xbm	62		m223.xbm
20		m52.xbm	63		m224.xbm
21		m54.xbm	64		m225.xbm
22		m56.xbm	65		m226.xbm
23		m57.xbm	66		m227.xbm
24		m58.xbm	67		m228.xbm
25		m5h.xbm	68		m229.xbm
26		m61.xbm	69		m230.xbm
27		m66.xbm	70		m231.xbm
28		m67h.xbm	71		m232.xbm
29		m67v.xbm	72		m233.xbm
30		m72.xbm	73		m234.xbm
31		m73.xbm	74		m235.xbm
32		m74.xbm	75		m236.xbm
33		m78.xbm	76		m237.xbm
34		m82.xbm	77		m238.xbm
35		m85.xbm	78		m239.xbm
36		m89.xbm	79		m240.xbm
37		m92.xbm	80		m241.xbm
38		m93.xbm	81		m242.xbm
39		m200.xbm	82		m243.xbm
40		m201.xbm	83		m244.xbm
41		m202.xbm	84		m245.xbm
42		m203.xbm	85		m246.xbm
43		m204.xbm			



Geological Survey of Western Australia



GSWA - Series Mapping Patterns — June 2017
Constructed with Adobe Illustrator CS6 — Map Production Manual Section - 17

'b' Patterns	b1	b1i	b2i	b3										
'c' Patterns	c1	c1-2	c1-3	c2	c3	c3-2	c3-3	c3-4	c3-5	c3-6	c3-7	c3-8	c4	c5
'd' Patterns	d101	d101-2	d101-3	d102	d105	d105-2	d105-3	d110	d110-2	d111	d112	d113		
'l' Patterns	l1	l11	l12	l13	l14	l102	l102-2	l103	l104	l107	l111	l112	l113	l114
'l' Patterns (cont.)	l114d	l115	l115d	l116	l118	l120								
'm' Patterns	m1	m1-2	m2	m2-2	m5	m5-2	m6	m6-2	m10	m10-2	m12	m12-2	m13	m13-2
'm' Patterns (cont.)	m14	m15	m16	m16-2	m19	m19-2	m19-3	m20	m20-2	m22	m22a	m22b	m22c	m22d
'm' Patterns (cont.)	m22-2	m23	m23-2	m24	m24-2	m25	m26	m26-2	m29	m30	m31	m33	m35	m36
'm' Patterns (cont.)	m36e	m38	m38e	m40	m41	m59	m59e	m59-2	m59-2e	m70	m70-2	m70-3	m70-4	m71
'm' Patterns (cont.)	m71-2	m74	m74-2	m75	m76	m76-2	m76-3	m76-4	m77	m78	m79	m79-2	m82	m82-2
'm' Patterns (cont.)	m85	m86	m90	m90-2	m91	m91-2								
'p' Patterns								p1	p2	p3				
'x' Patterns													x1	x2
named Patterns	m	paw1	paw2	paw3	w	waves								