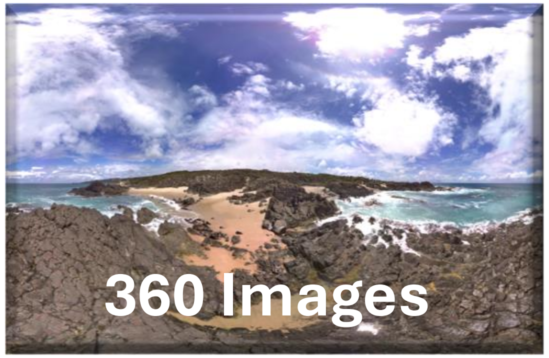
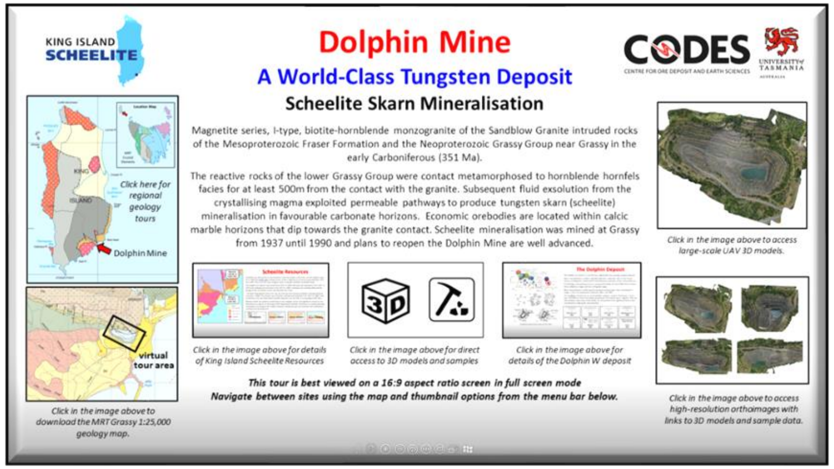
Virtual Tour Production





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Erasmus+
Enriching lives, opening minds.

UNIVERSITY of TASMANIA

CODES

Background

This electronic guide has been developed to assist in production of immersive virtual tours and educational objects for the Erasmus + project: **Immersive Virtual Tours on Critical Minerals for Clean Energy Transitions** (**IMMERSE**).

The guide describes proposed spatial data capture, data processing procedures, and software for virtual tour production.

The guide is designed to help standardise tour production processes across participating organisations and also to provide a framework for other parties to help develop similar resources.

Erasmus+

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IMMERSE Participating Organisations

MRE Institute of Mineral Resources Engineering | RWTH AACHEN UNIVERSITY

CODES

UNIVERSITY of TASMANIA

Department of Earth Science

Universidad de Huelva

School of Mineral Resource Engineering

Technical University of Crete

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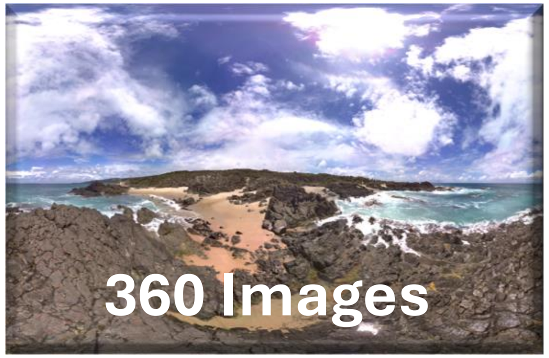
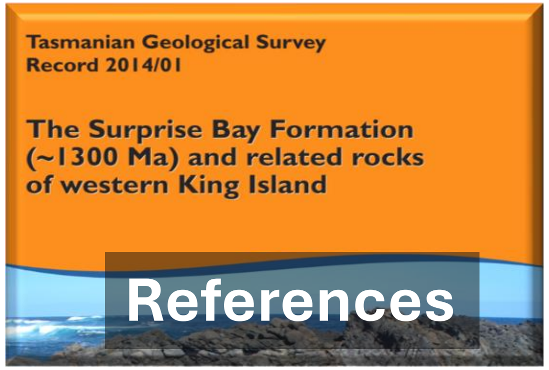
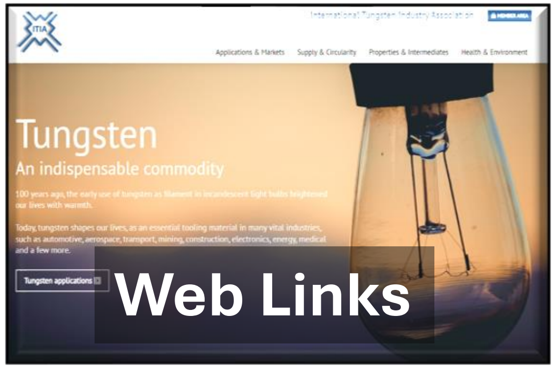
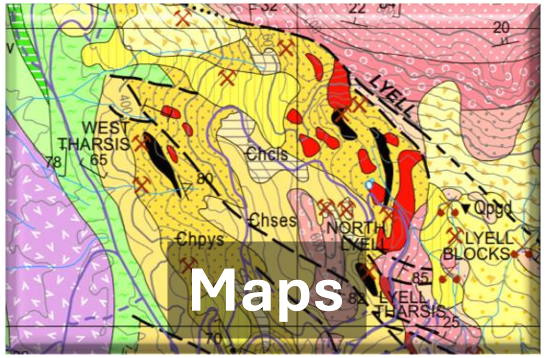
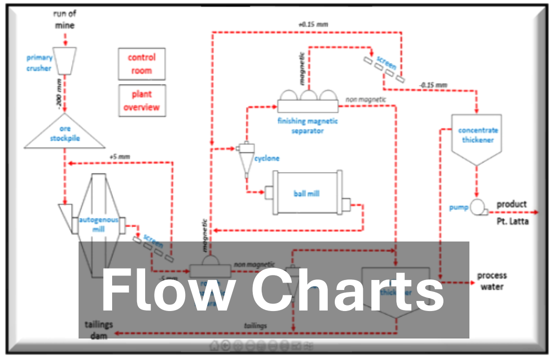
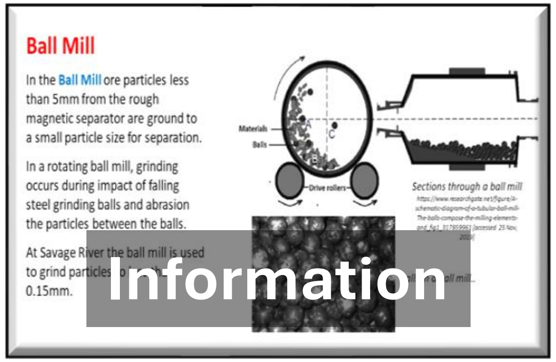


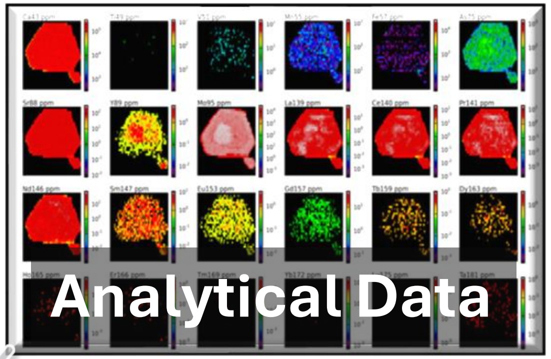


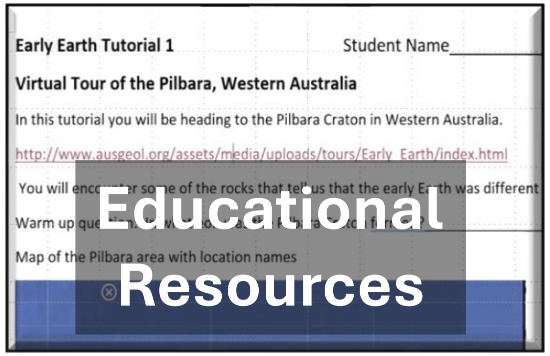












360 Degree Imagery

360 degree imagery or **Full Spherical Panoramas** (**FSPs**) form the basis of most immersive virtual tours.

FSPs provide an immersive 360 degree view of a locality that cannot be provided by conventional photography.

FSPs are simply conventional equirectangular jpeg or tiff images with a 2:1 aspect ratio that can be edited in image processing software.

To view an image in 360 degrees requires special viewing software such as: [FSPViewer]

Example 360 Degree Imagery

360 DSLR Images

DSLR

Manual Panorama Head
Stitch fisheye images
6 images - >140 Mpixel

Digital SLR cameras mounted on manual or motorised panorama heads were conventionally used to acquire 360 degree imagery.

These systems can provide the highest quality and highest resolution images but require post-processing to stitch multiple images together.

Suitable software for manual stitching panoramas include:

[HUGIN (Free)]

[PTGUI (Commercial)]

Follow hyperlinks to access software sites.

DSLR

Auto Panorama Head
Stitch multiple images
140 Mpixel - Gigapixel

360 Degree Cameras

Modern consumer 360 degree cameras use multiple synchronised cameras (up to 25 lenses) to acquire a 360 degree image with a single button press.

These are currently the fastest and most convenient way to acquire 360 imagery for virtual tours.

Some post processing using dedicated software and image processing systems may be required to 'level' and adjust image contrast.

High resolution cameras (>8k resolution) are required to provide suitable resolution for virtual tours.

Examples of suitable modern 360 cameras are:

Xphase Pro S
16 k (~134 Mpixel)
Stills Only

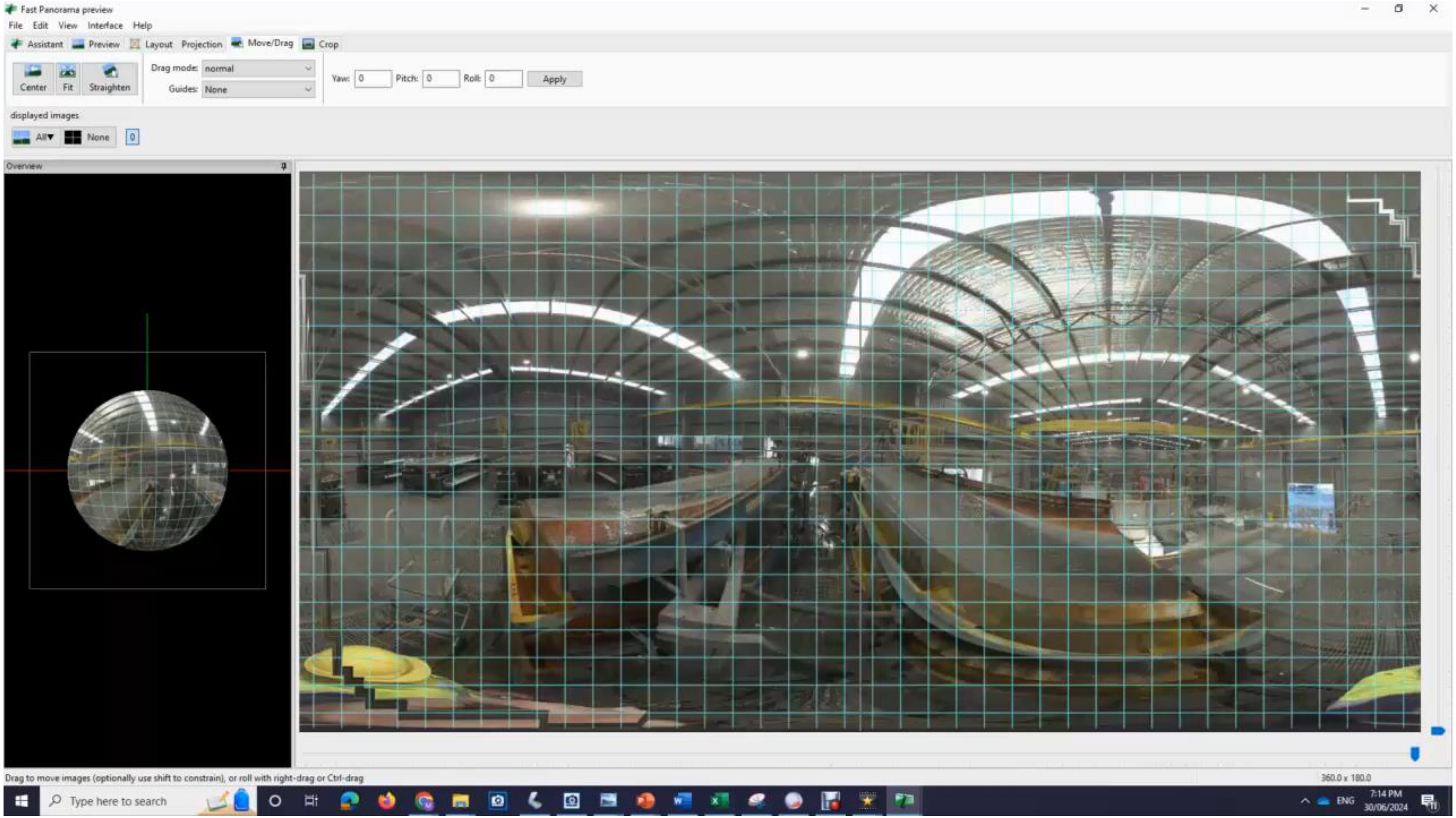
[Xphase Pro]

[Insta360 X4]

Insta360 X4
11 k (~72 Mpixel)
Stills and 8k video

Follow hyperlinks to access hardware sites.

Example Xphase 360 Image



360 Aerial Images

Drone Imagery

Hover and rotate
Stitch multiple images
35 images - >250 Mpixel

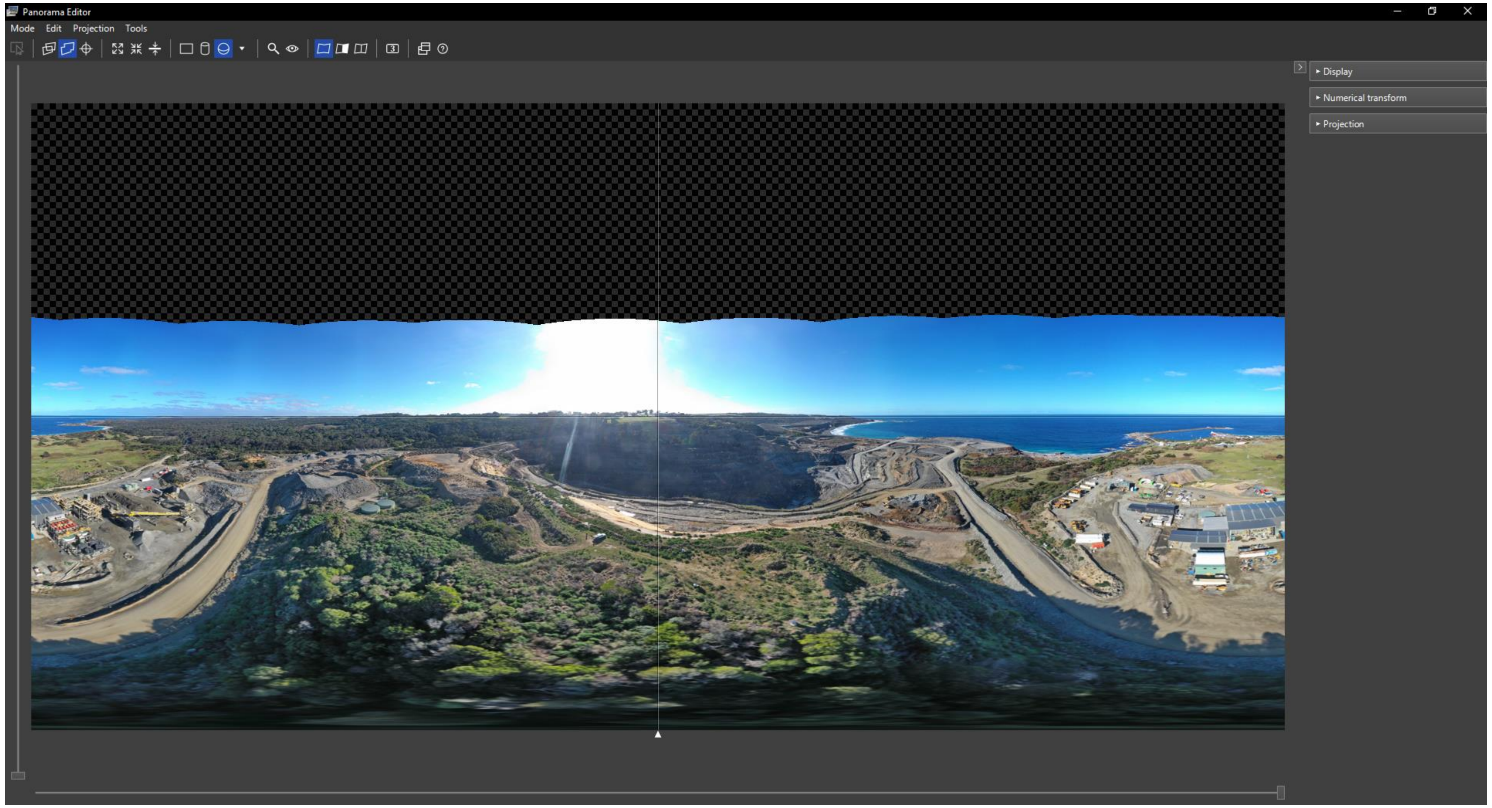
360 degree imagery acquired from an aerial perspective provides an excellent way to provide overall site context.

These images are acquired by hovering the drone at a fixed location and collection of multiple images (40-60) at different azimuths and inclinations.

Highest resolution images are generated by post-processing and stitching raw imagery.

Image acquired with a Mavic 2 drone in this way are ~350 Mpixel.

Example Aerial 360 Image



56 images acquired at different azimuths and inclinations.

Batch post-processing to balance image tone, brightness and contrast.

Stitched equirectangular image in PTGUI.

365 MPixels

Drones cannot image the sky above so this area is filled with black.

Example Aerial 360 Image

3D Models

3D photo-realistic models can be incorporated into tours if geometric features and relationships are important for example in structural geology or strata control.

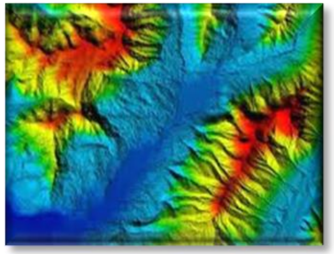
3D models can be generated using digital photogrammetry or using laser scanning.

Models can be created at any scale from 100s of metres (drone), to mine exposures and outcrops (terrestrial photogrammetry, 1 – 10s of metres), to rock samples (desktop systems)

At this stage (2024) 3D models are most conveniently stored and delivered into virtual tours using Sketchfab.

Digital Photogrammetry

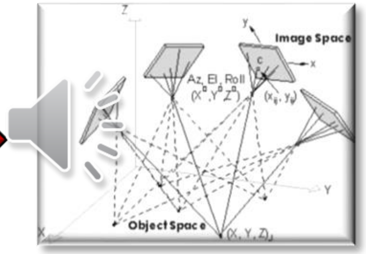
Reprojection
orthophoto



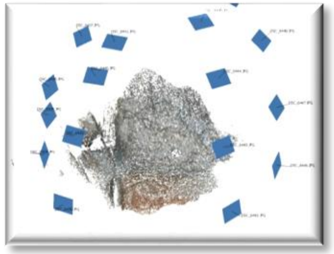
Interpolation
DEM

Image Capture
digital camera

Feature Selection
SIFT Algorithm

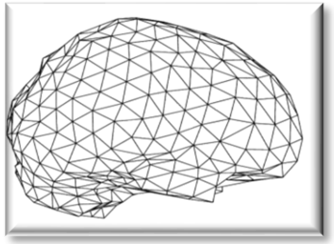


Bundle Adjustment
Interior and exterior



Geometry Infill
dense point cloud

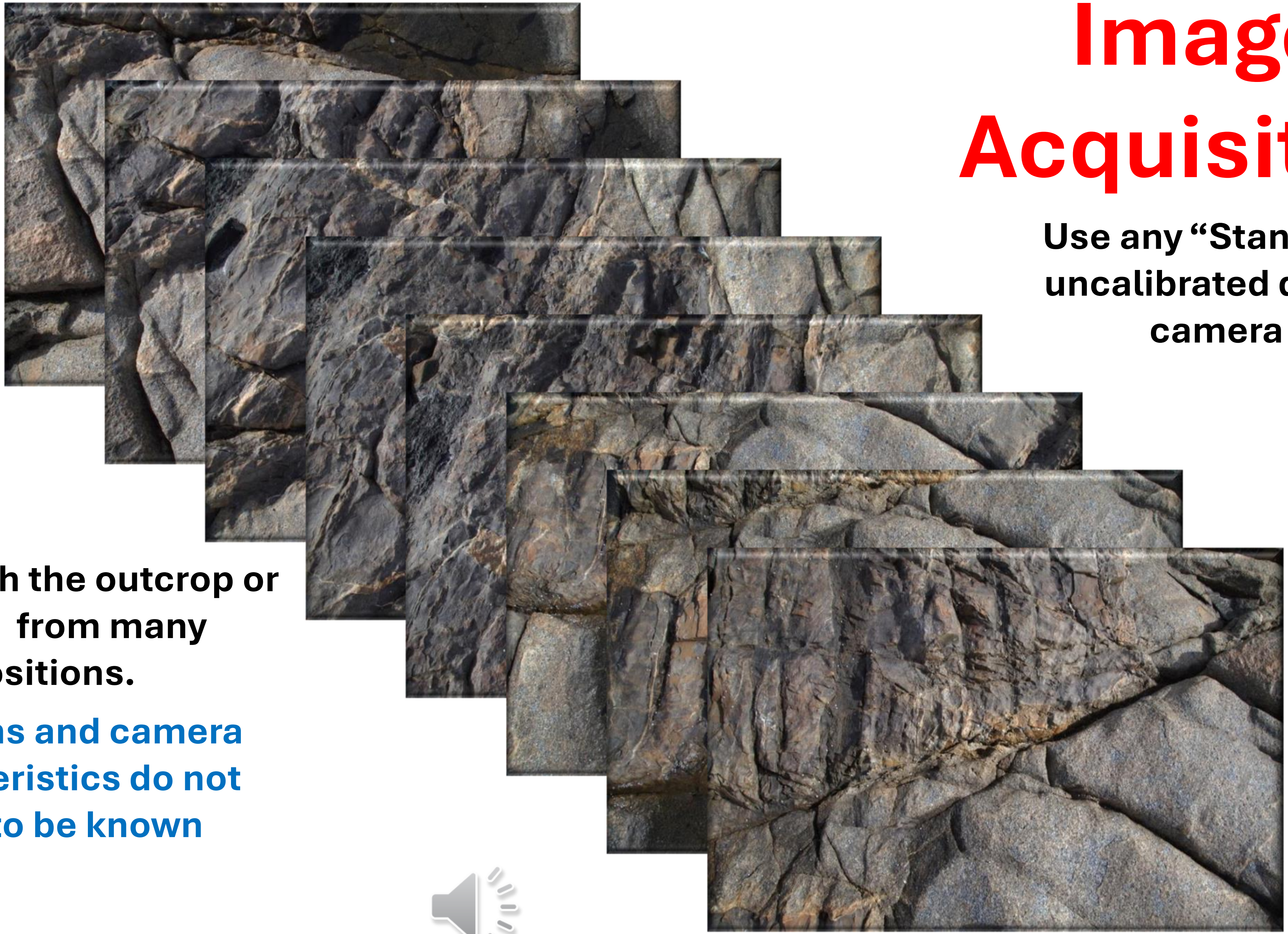
Texture Mapping
photo-realistic model



Mesh Generation
3D model

Image Acquisition

Use any "Standard" uncalibrated digital camera



Photograph the outcrop or object from many positions.

Locations and camera characteristics do not need to be known

Photography Guidelines

Any camera will work (DSLR, point and click, mobile phone, GOPRO etc).

Need to know how to use your camera!!

Automatic settings are OK if lighting is uniform but can be an issue if lighting is irregular.

Best to shoot in manual mode to ensure constant balance and exposure.

RAW vs JPEG

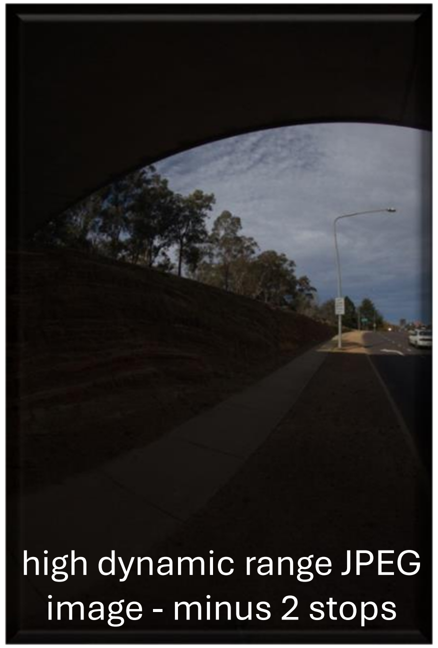
If your camera allows, best to shoot in RAW

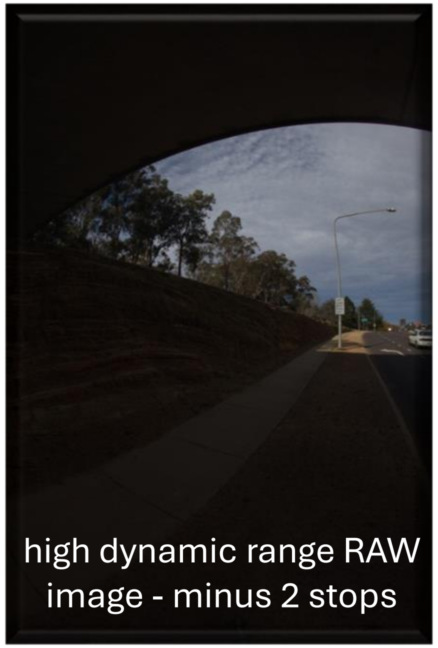
RAW files will be larger and require conversion to JPEG for some processing steps but it is possible to do much more with a RAW file……

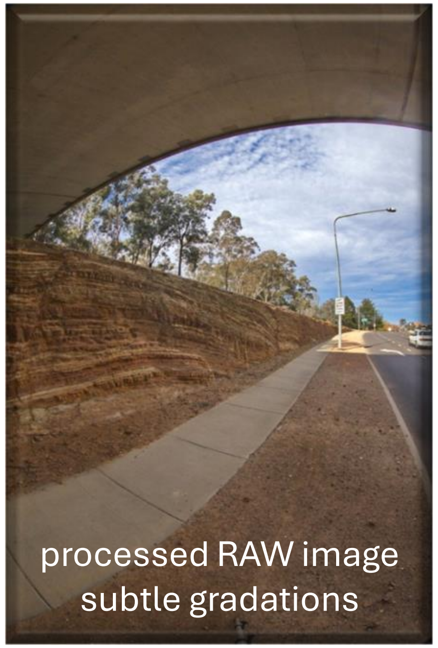
JPEG files : lossy compression - 8 bits (256 shades) per colour per pixel

RAW files : non-lossy compression 14 bits (16384 shades) per colour per pixel

Extra bit depth is particularly important in contrasting light conditions to recover detail from shadow areas.







White Balance

In automatic modes, most cameras set white balance for each frame and imagery may have different tonal qualities in different directions with different lighting.

Set the balance for JPEG shooting!

White balance can be corrected by post-processing RAW files but not easily in JPEG.

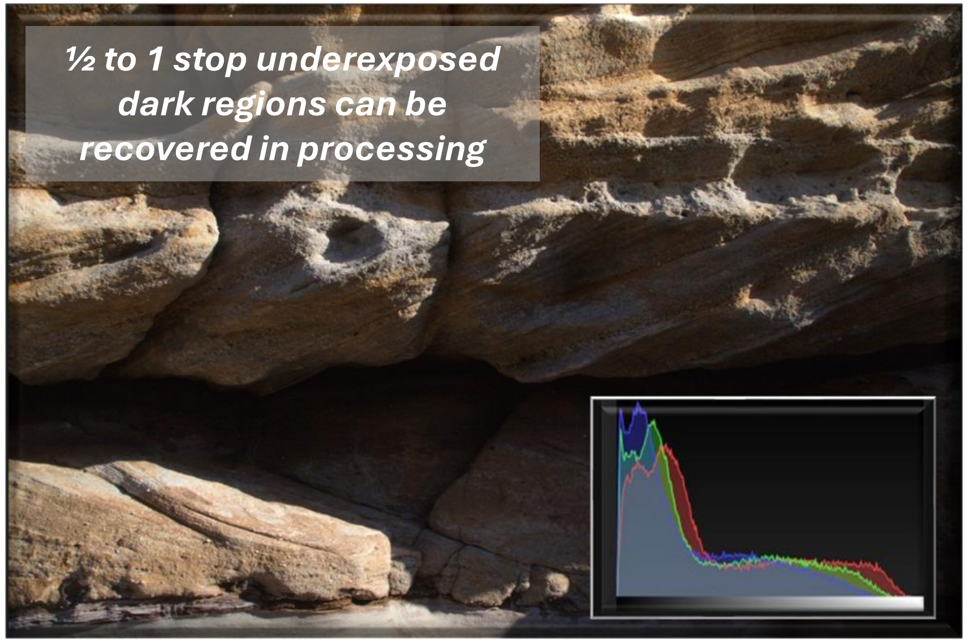
Image Exposure

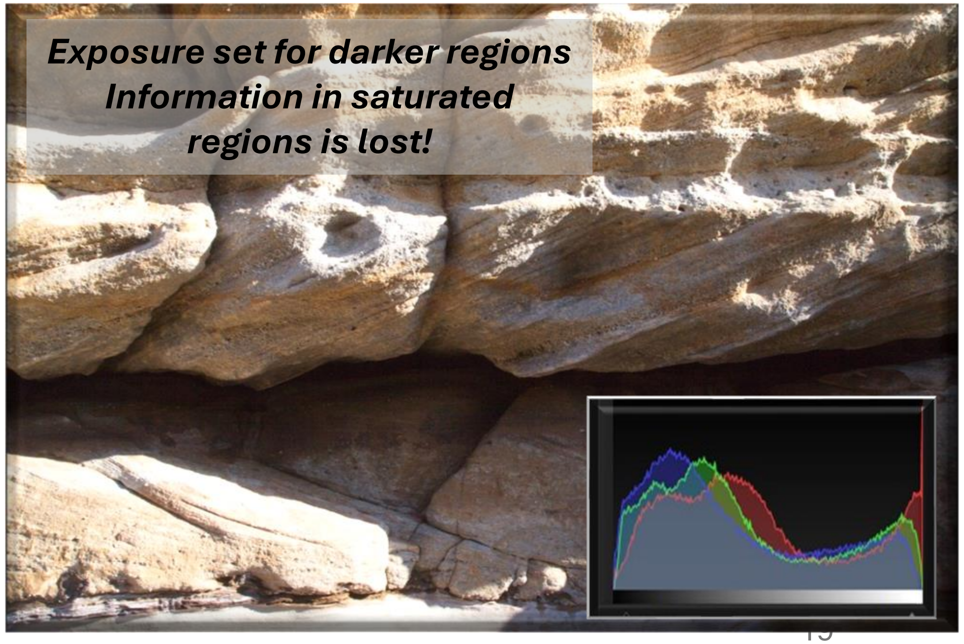
In uniform lighting conditions automatic exposure is OK but if there are major contrasts then manual exposure is better.

Explore the object to find the brightest area and set manual exposure for this region.

Best to aim for ½ stop underexposed. Overexposed (saturated) areas cannot be recovered by processing.

Dark regions of the outcrop may initially appear to be very under-exposed but this can usually be recovered in processing (particularly with RAW images)





Depth of Field

Always shoot to achieve a large depth of field (closed aperture / large f stop) to allow identification of features at a range of distances from the camera.

Depth of field is particularly important for close-range and macro photography.

Unless absolutely necessary, don't shoot slower than 1/50 sec to avoid motion blur (although lower speeds can sometimes be used if the camera has image stabilisation).

In low light it is OK to increase sensitivity (higher iso) in order to try to obtain suitable depth of field. Modern sensors are good (not grainy) below ~iso 640.

Field of View

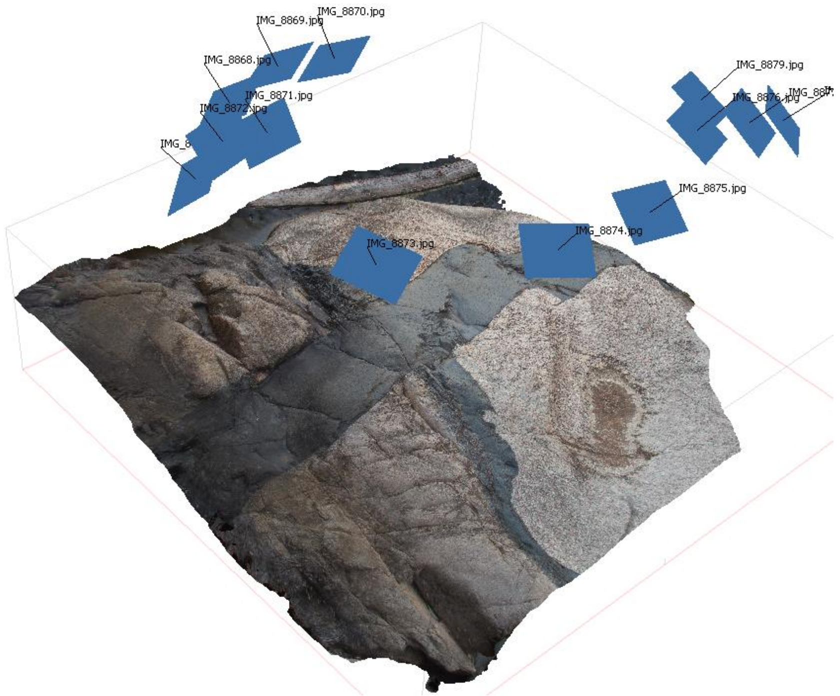
3D reconstruction relies on imaging the same points from multiple locations and the field of view of the lens or sensor affects the quality of reconstruction and the number of images needed.

It is generally best to come in close and use a wide angle lens (~24-28mm on full frame DSLR). This maximises the view angles to peripheral points.

For macro photography 100mm is OK but more frames, from a range of viewpoints, are required to image complex objects.

Fisheye lenses will work but the geometric reconstruction is generally of lower quality.

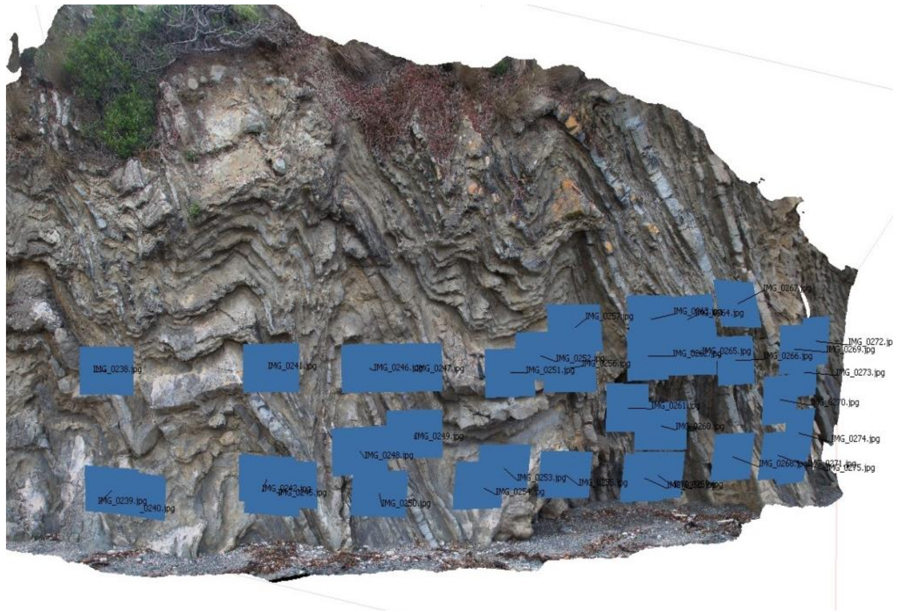
Number of Images



3D reconstruction relies on imaging the same points from multiple locations – best to move the camera for each frame.

All features that need to be imaged in 3D should appear in at least three images.

For geometrically simple objects 6 to 8 images may be sufficient for good reconstructions.



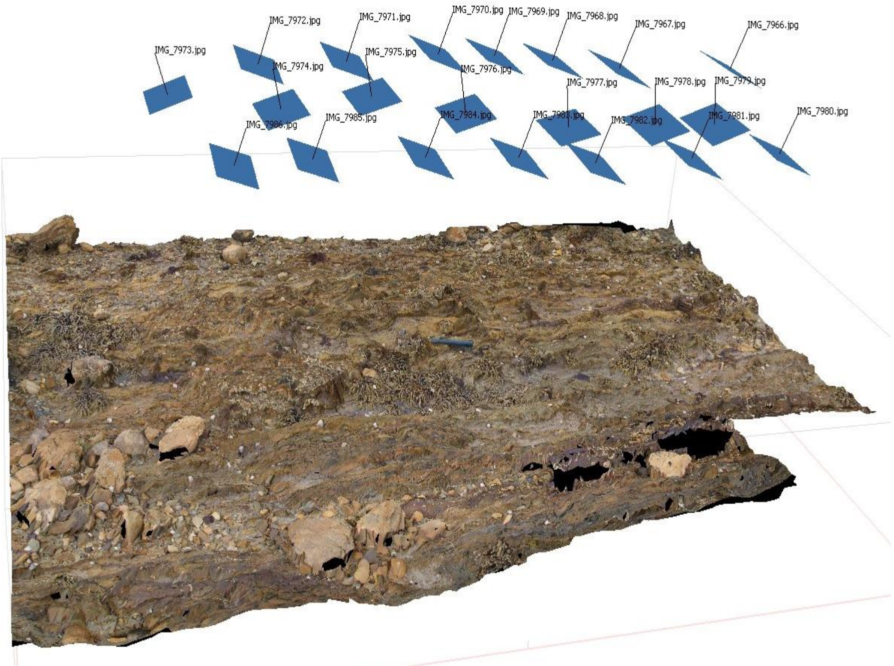
For complex objects many images may be needed to resolve the irregular geometry.

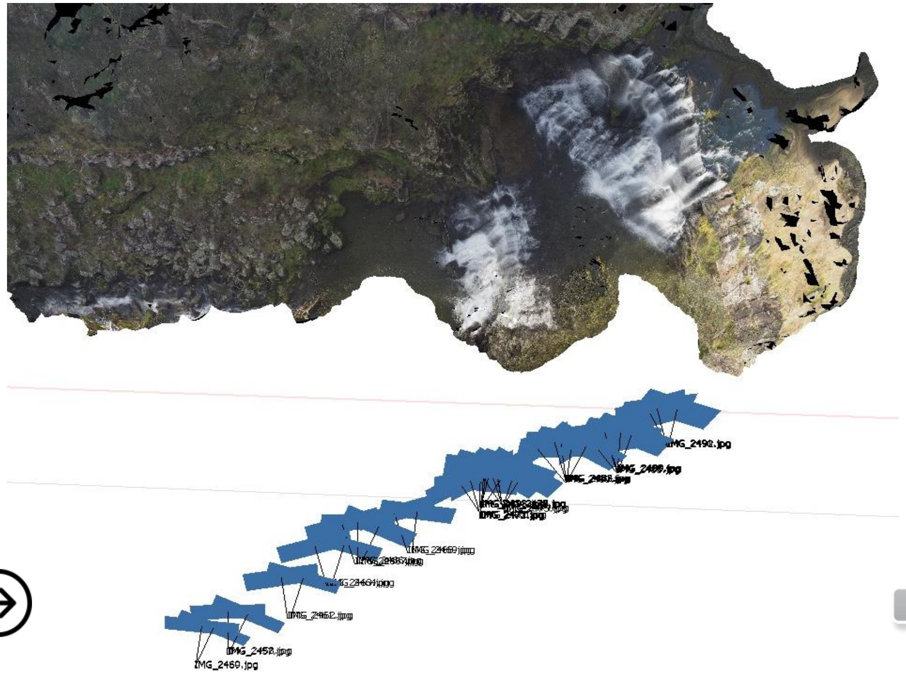
No simple rule – if in doubt, collect extra images!

Image Geometry

Visualisations of large 'flat' outcrops (pavements or cliff faces) can be achieved by systematic orthogonal and oblique photography

Set the camera to wide angle and collect images with minimal overlap looking 'backwards', straight ahead and 'forwards' before moving to a new location.





When access is limited 'fan shooting' (multiple images from the same location) can be used.

In fan shooting can lead to poor geometric models or result in failure of the geometric reconstruction algorithm.

Scale and Location

All 3D visualisations should include some indication of scale.

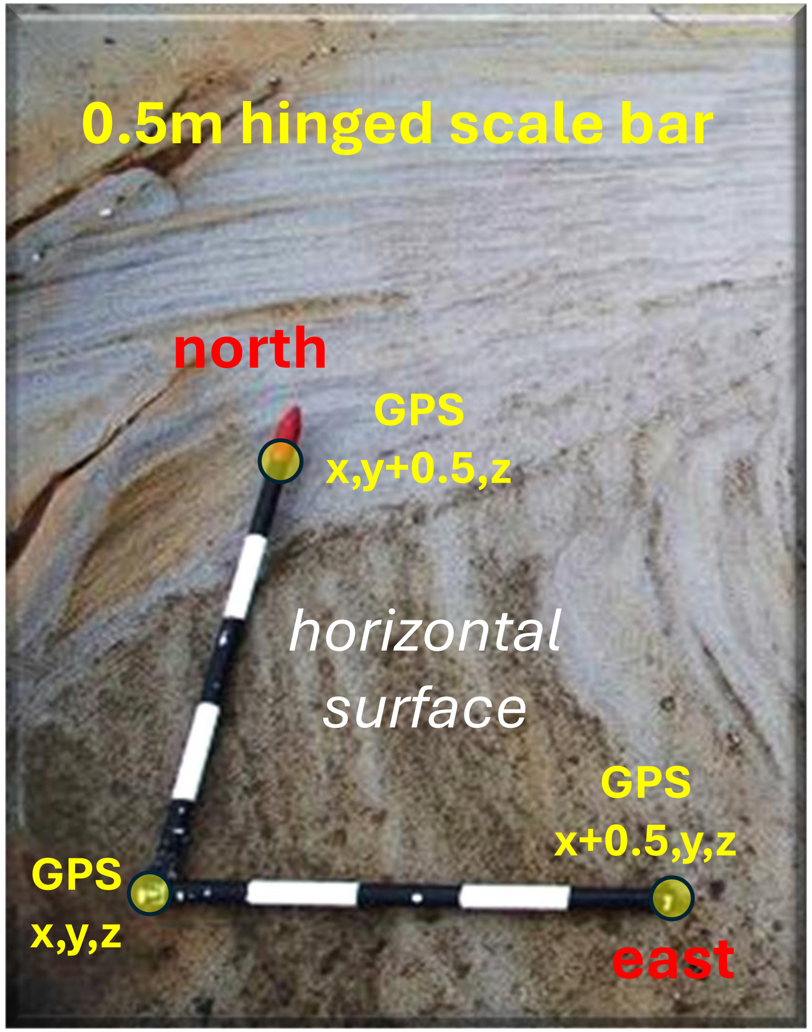
Hammers, lense caps, coins etc can be used but these do not easily allow full georectification of the 3D object.

3D georectification requires at least a 2D scale for which three 3D coordinates can be provided.

Hinged 0.5 or 1m scale bars are suitable for georectification of objects up to 5-10m.

For larger visualisations control point markers can be deployed (DGPS, tape and compass)

Georectification



For many 3D models it is desirable that the visualisation is correctly scaled, orientated, and placed in a cartesian coordinate system.

Georectified models can then be used for measurements of distances, angles, areas and volumes.

Imagery acquired using drones usually has gps positioning which simplifies georectification.

For terrestrial photogrammetry, features such a hinged scale bars or geological compasses can be used.

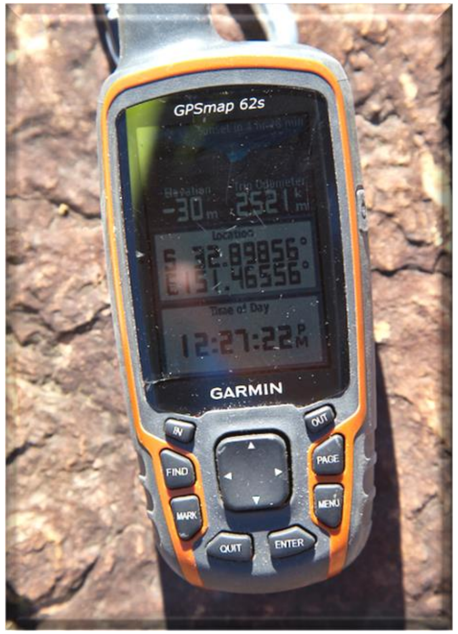
If possible, place the scale object horizontally in the scene oriented with respect to grid north.

Handheld GPS coordinates can then be ascribed to three points on the scale object for georectification.

Image Management

Photogrammetric imaging may involve collection of thousands of images from many sites each day.

In some cases it can be difficult to identify the start and end of each photographic sequence during later processing.



Start with a GPS photo

(provides time and a cross check with coords in your notes)

Finish with a 'sky' photo

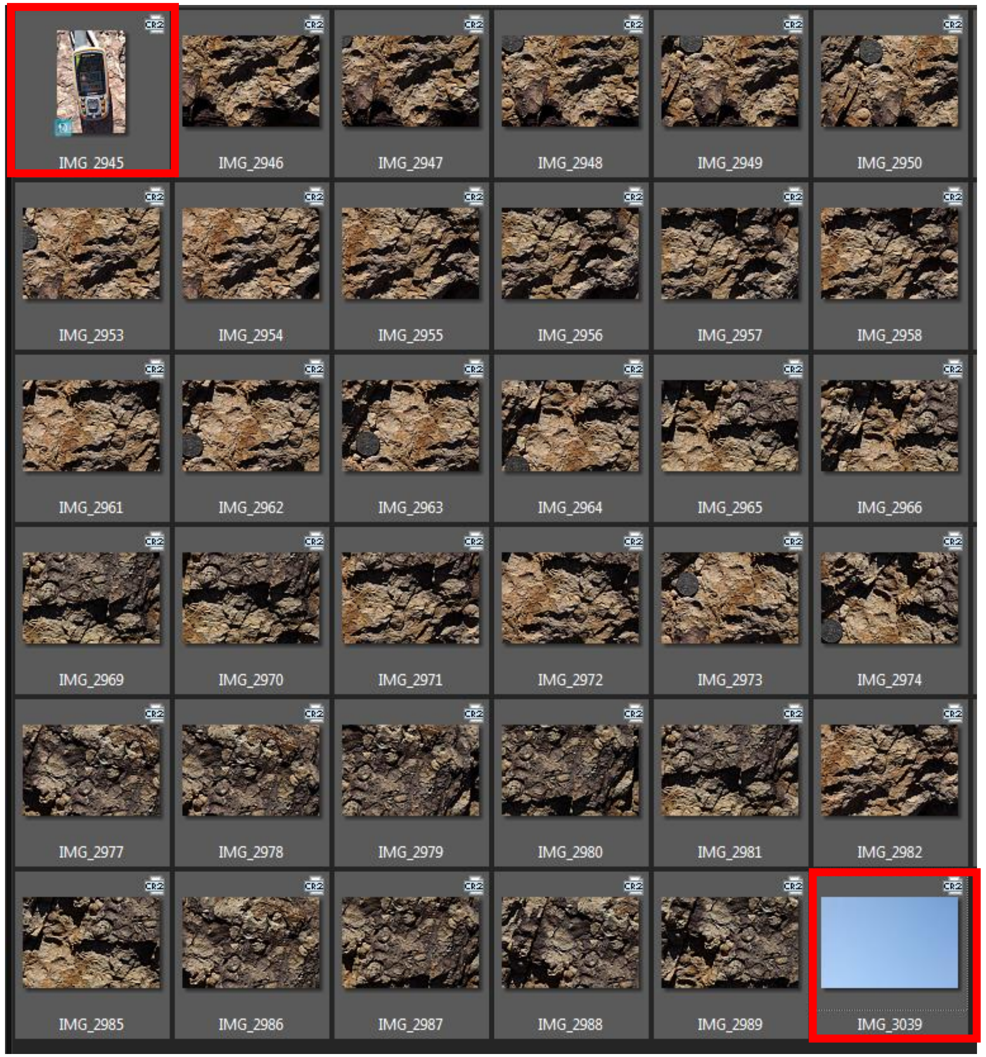


Image Processing

Image processing steps should be applied consistently with the same parameters to all images in a visualisation sequence.

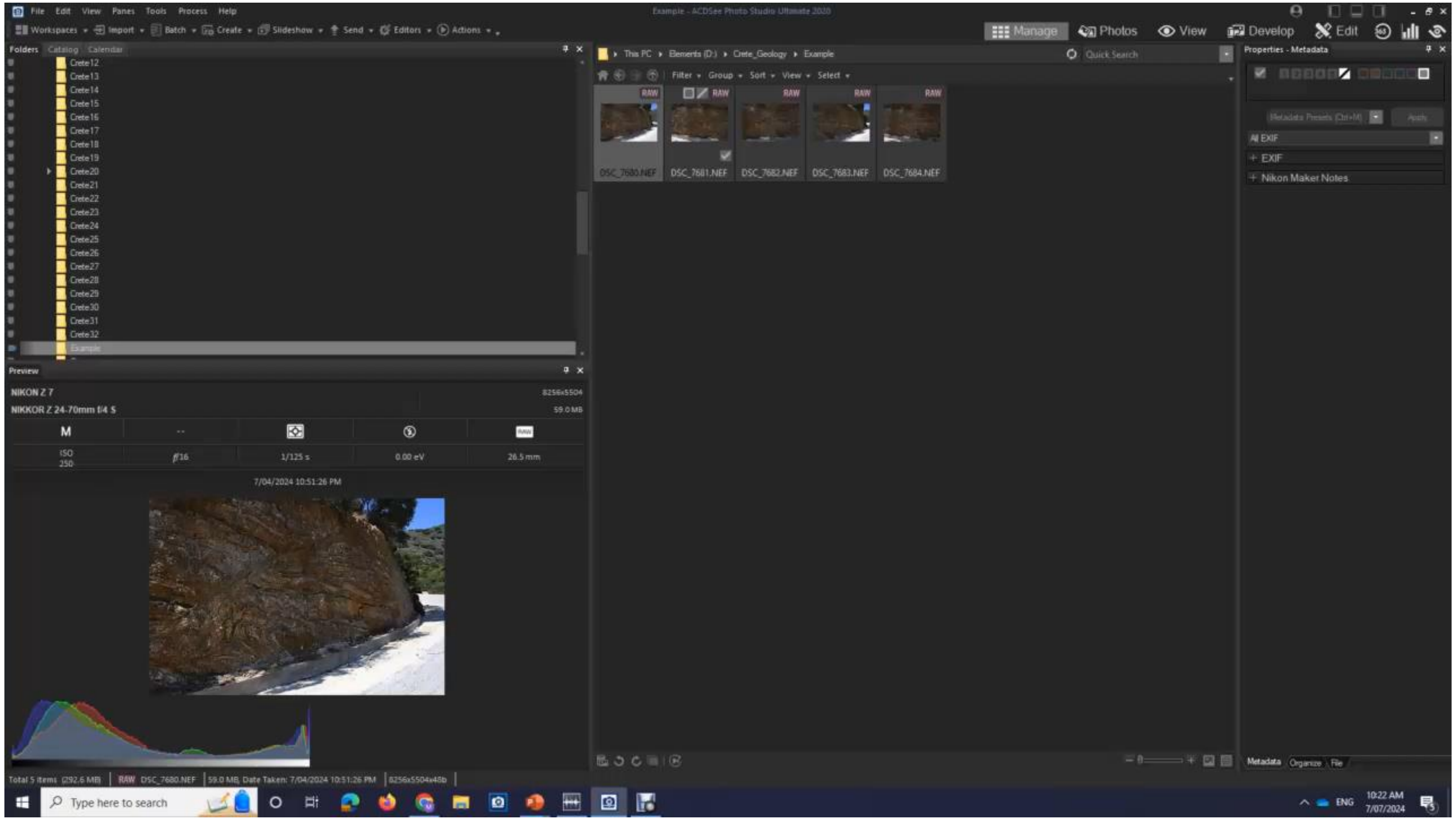
Batch image processing software:

[Lightroom]

[ACDSee]

[GIMP] ([BIMP])

Follow hyperlinks to software sites.

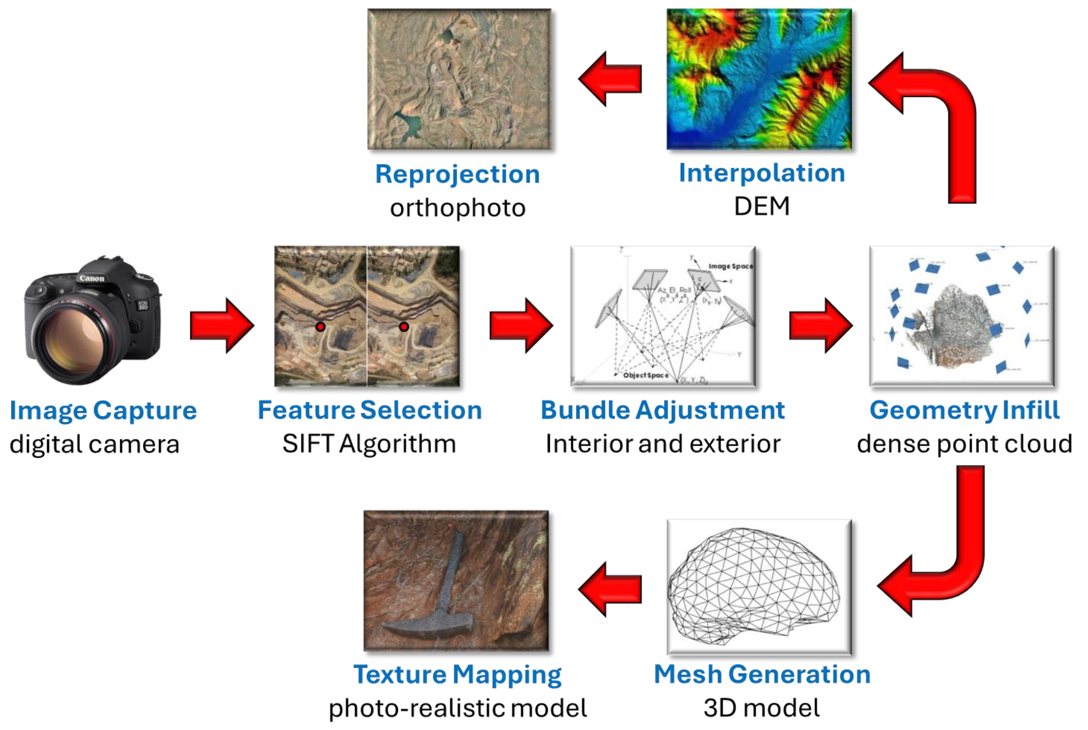


Photogrammetric Processing

There are many different software packages and web services for processing photogrammetric data from close-range, terrestrial and drone images but all use the same basic processes.

Photogrammetry begins with automatic identification of common points using the SIFT algorithm which can locate these features in images collected at different scales and from different viewpoints.

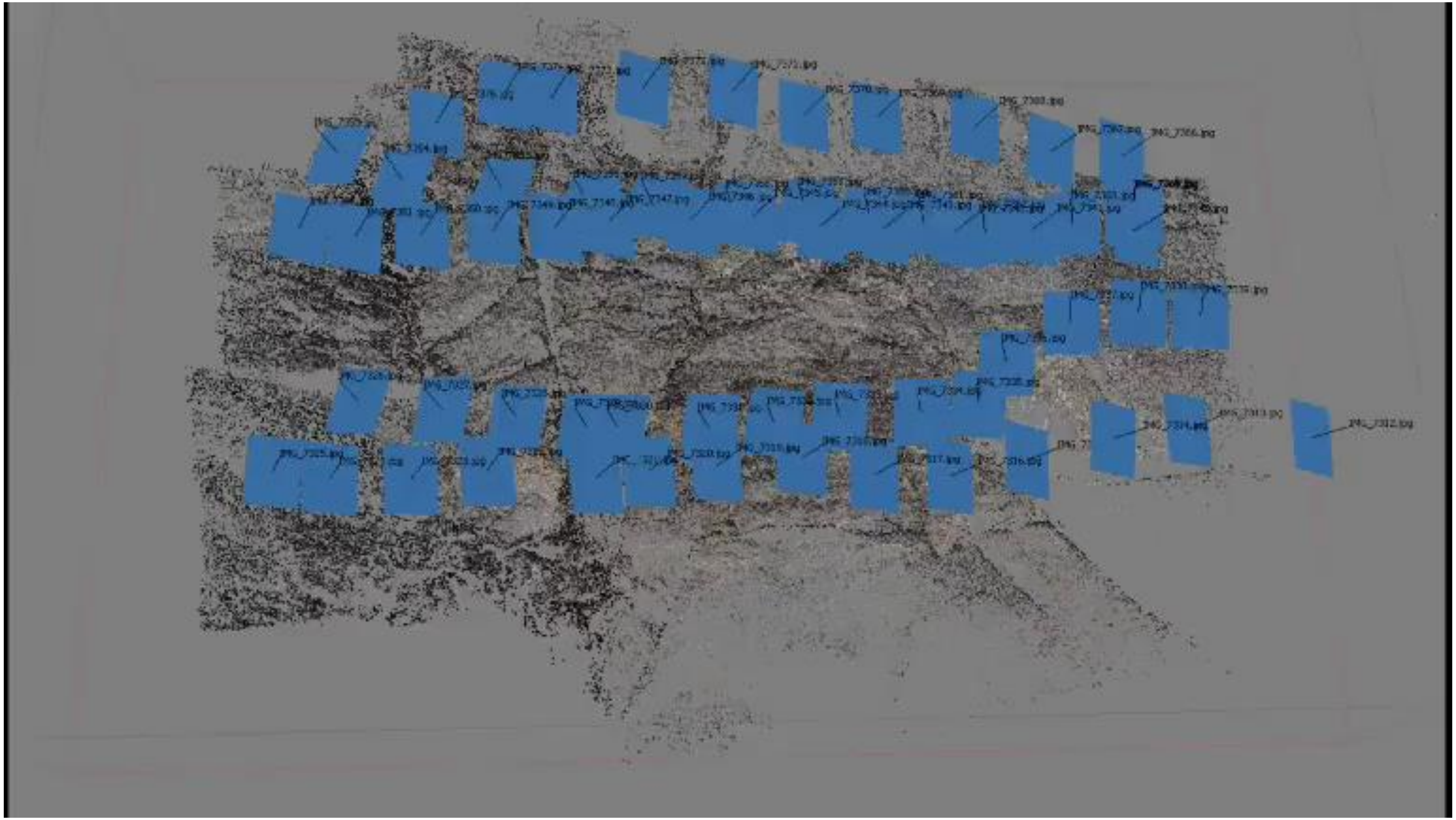
Camera positions and parameters are then determined from the SIFT points to generate point clouds (sparse and dense).



Triangulation of point clouds generates a 3D model

The triangulated 3D model is texture-rendered to create a photo-realistic 3D virtual model

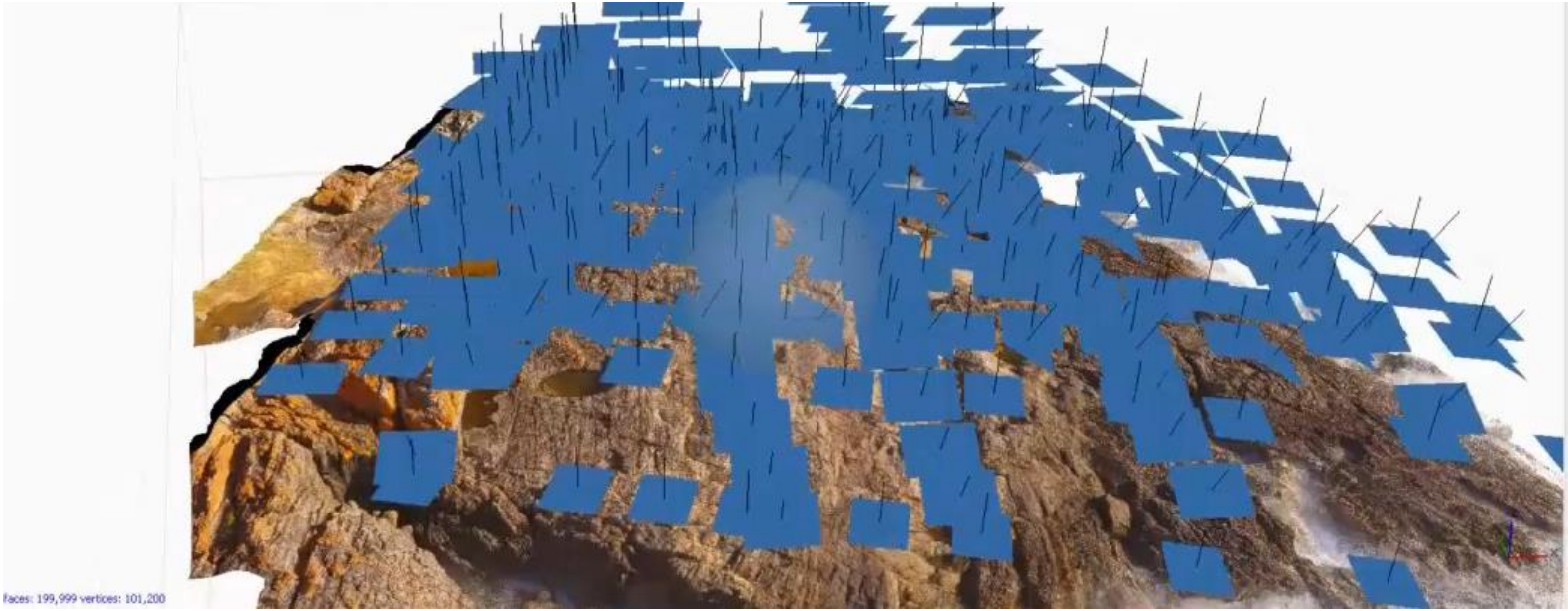
Terrestrial Photogrammetry



Faulted granite contact – Picaninny Point, NE Tasmania

Close Range Photogrammetry

Drone Photogrammetry



Coastal Outcrop, Piccaninny Point, Tasmania

Airborne Photogrammetry

Many significant geological features are too large and inaccessible to visualise using terrestrial or drone imagery.

Fixed wing or rotary aircraft can be used (expensive but fast)

Federation Peak, SW Tasmania

1.8 x 1.4 km , 650m vertical
three passes ~ 5 minutes ~650 images

Laser Scanning

Laser scanners are the most accurate method for capturing geometry. Survey scanners can work up to 100s of metres. Handheld scanners are useful for small objects (0.1- 2m). These systems are expensive.

Modern Apple iPhones and iPads have laser (LIDAR) sensors that are not as accurate as dedicated scanners but which can be used to produce 3D models suitable for educational purposes.

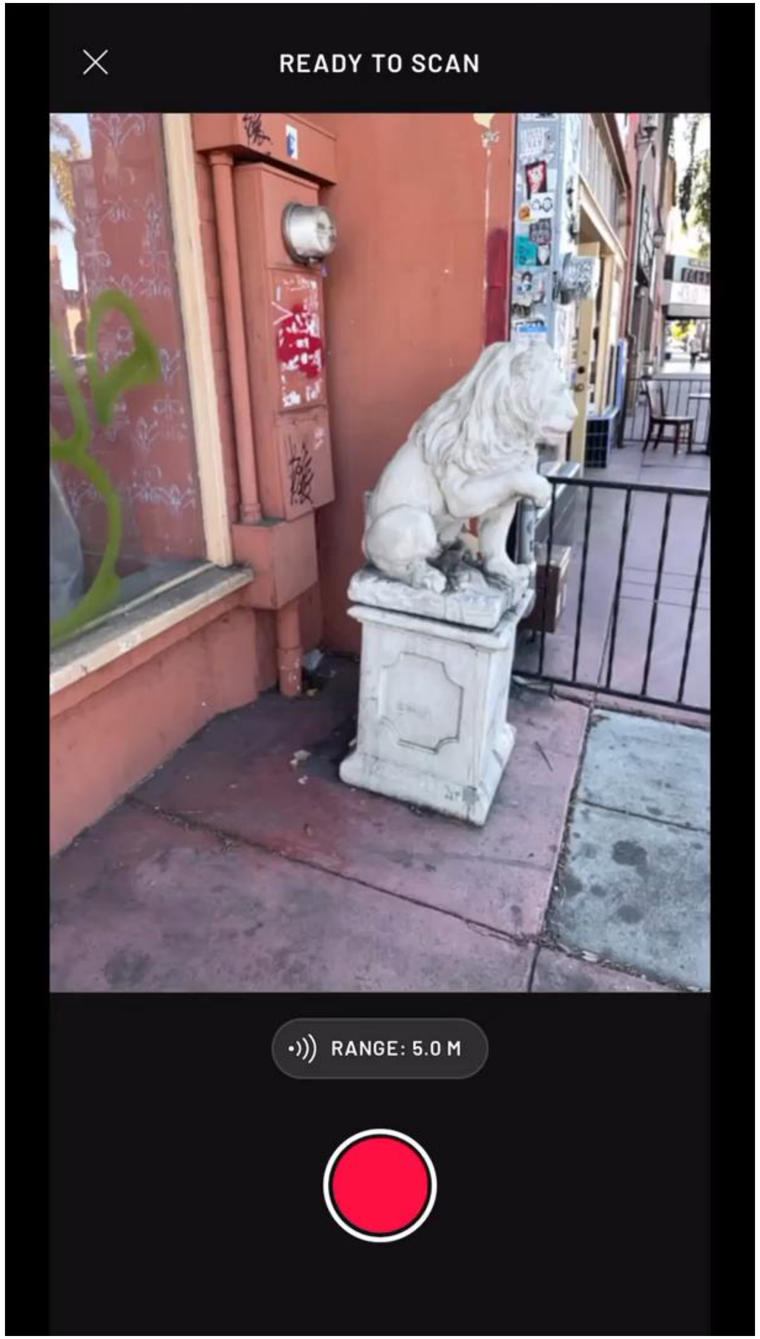
Scaniverse

There are many applications for Apple laser and photogrammetry imaging.

I have tested the app Scaniverse and found that it works reasonably well for small to medium-sized objects.

The maximum model size for the Apple LIDAR scanner is determined by the scanner range (~5m) and scanning duration (~4-5 minutes).

Scaniverse now also offers a new method for 3D representation called Gaussian Splatting which may have advantages for capturing complex objects but this has yet to be tested for virtual tours.



Scaniverse vs Photogrammetry

Terrestrial Photogrammetry
Nikon DSLR

Click on the labels to hyperlink to 3D models.

Scaniverse
Apple iPad

Scaniverse iPad models give ~80% output quality for ~15-20% of the effort.

Sketchfab

Sketchfab is a hosting service for 3D models (like YouTube for videos)

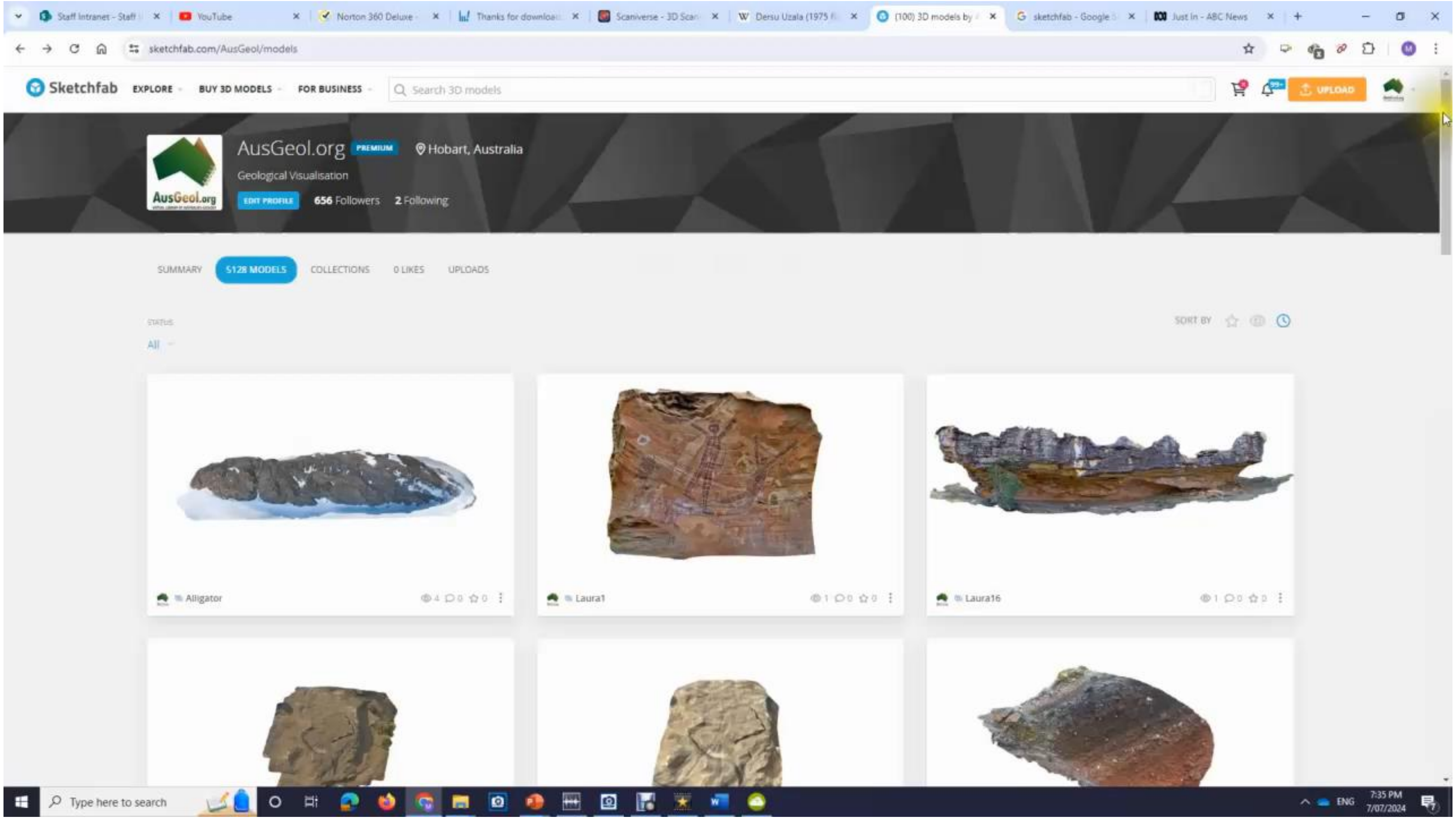
Sketchfab provides the most effective way to share 3D models and to serve them in other applications such as virtual tours.

Need to register for a free educational licence that allow up to 200 uploads per month are available

Most photogrammetry and laser scanning software provide options for automatic upload of 3D content to Sketchfab (need an API number).

Standard 3D file formats can also be uploaded (eg: .obj, .fbx, .ply etc)

Sketchfab Example



Deep Zoom Imagery

When imaging geological features we often want to see both the context and the detail (both the forest and the trees)

Even modern DSLR cameras (50 Mpixel), do not allow resolution of features at multiple scales

Deep zoom ‘gigapixel’ images can allow facilitate this aim and be delivered seamlessly in web-based applications.

‘Gigapixel’ Photography

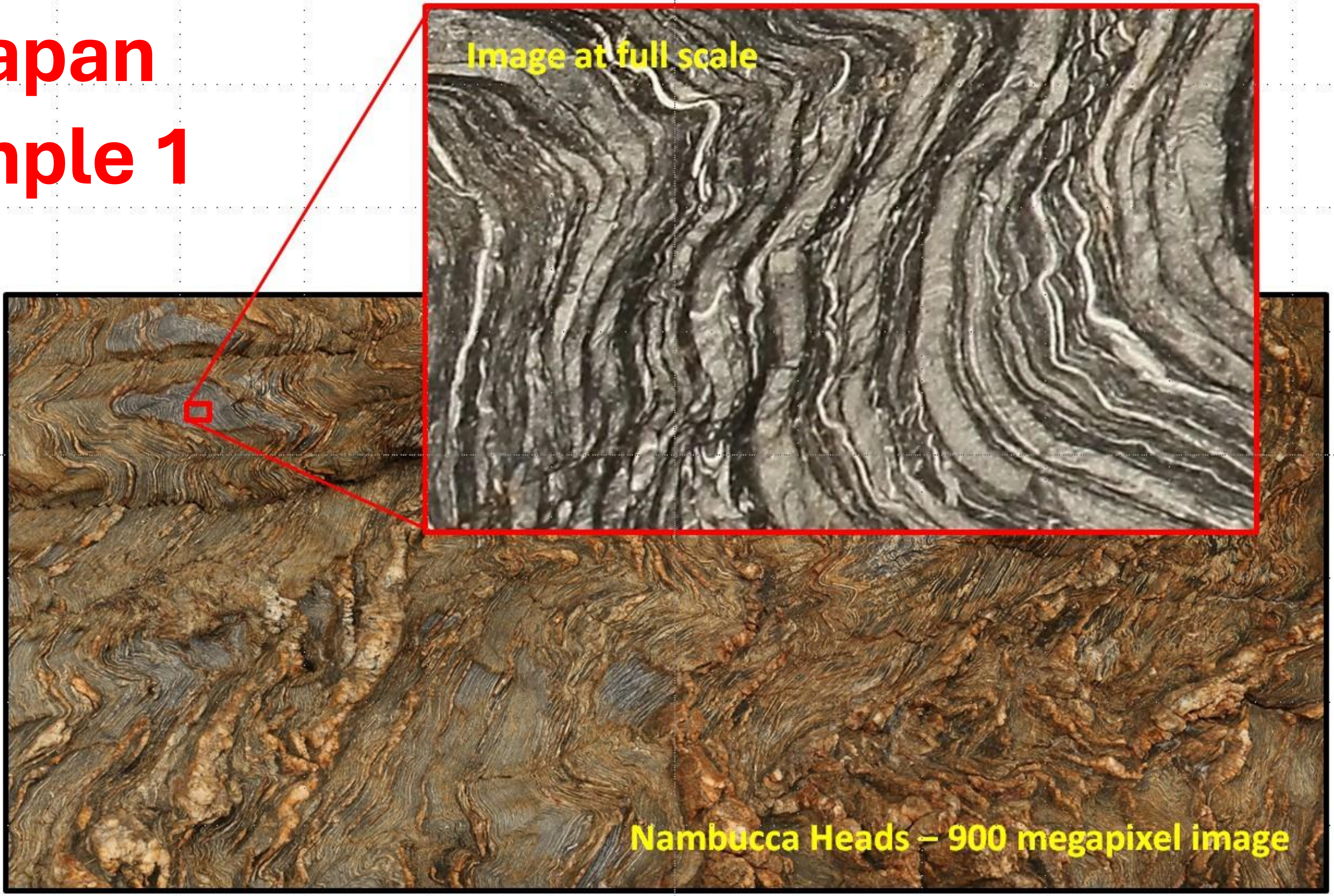
Robotic camera heads and long focal length lenses allows capture of amazing detail over large areas.

Multiple images can be seamlessly combined to produce gigapixel imagery

Good results require high density sensors and good optics.

Multi-resolution data storage and wavelet compression allow seamless display of multi-gigapixel images.

Gigapan Example 1

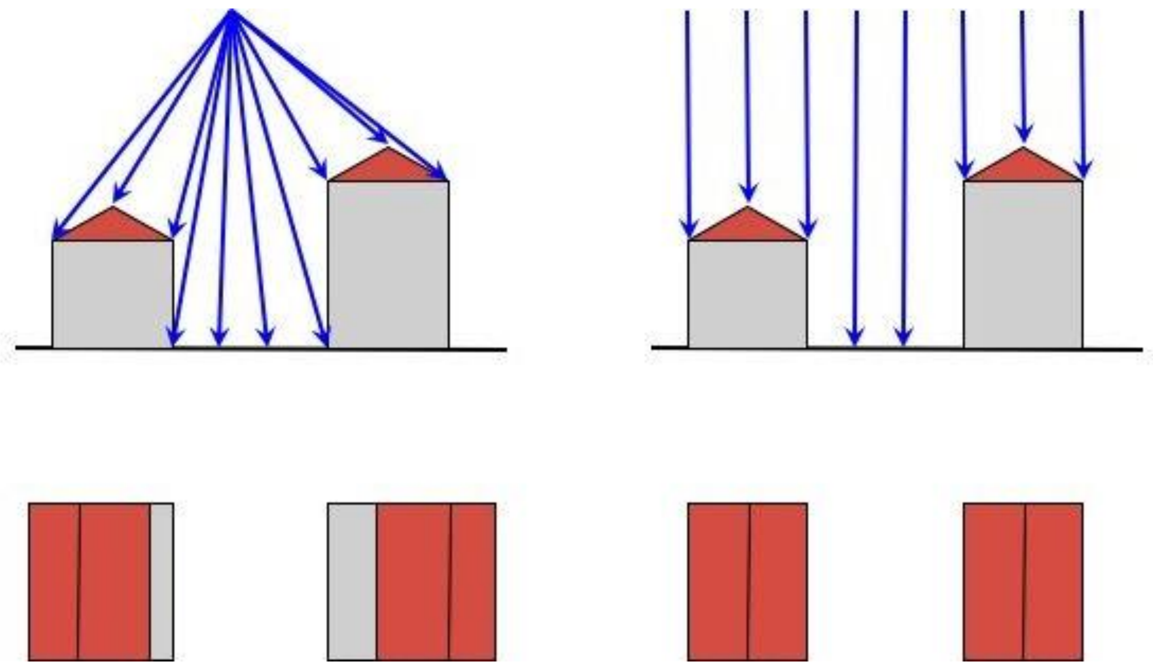


Gigapan Example 2

Mesozoic sedimentary strata faulted against Tertiary volcanic rocks – Maipo Valley, Chile

1600 Mega Pixels – multi-resolution format ~600 Mb.

Orthoimagery



Conventional photography views a location from a single vantage point with diverging light paths.

Orthoimagery depicts a region as though it was imaged using parallel light paths generally orthogonal to the surface.

Traditional vertical orthoimagery is generated from aerial photography using photogrammetry.

However, orthoimages do not need to be vertical but can be generated in any direction from a digital photogrammetric model.

Orthoimagery can be used to generate deep zoom imagery.

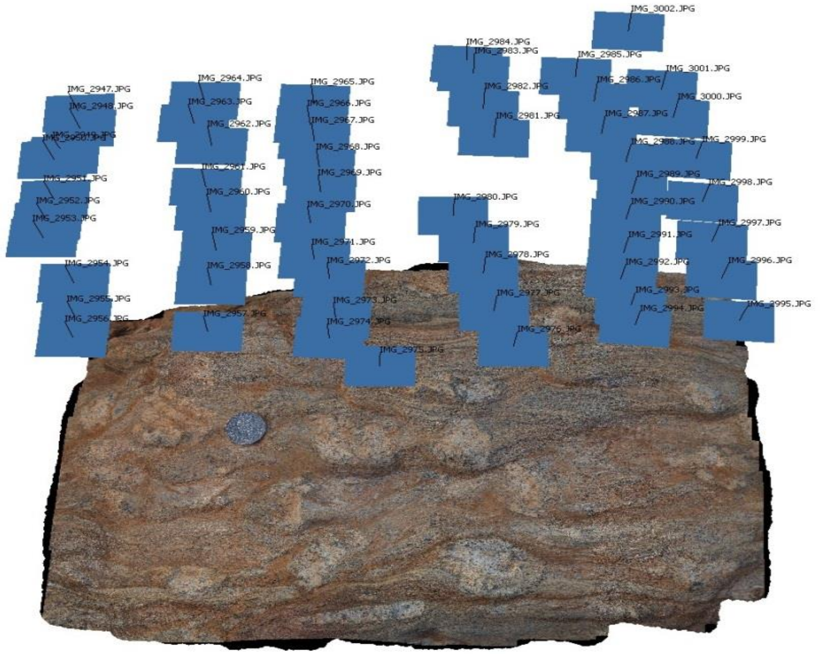
Close-Range Orthoimagery

For close subjects, focus issues and depth of field have a major negative impact on the quality of gigapixel imagery acquired with robotic camera heads.

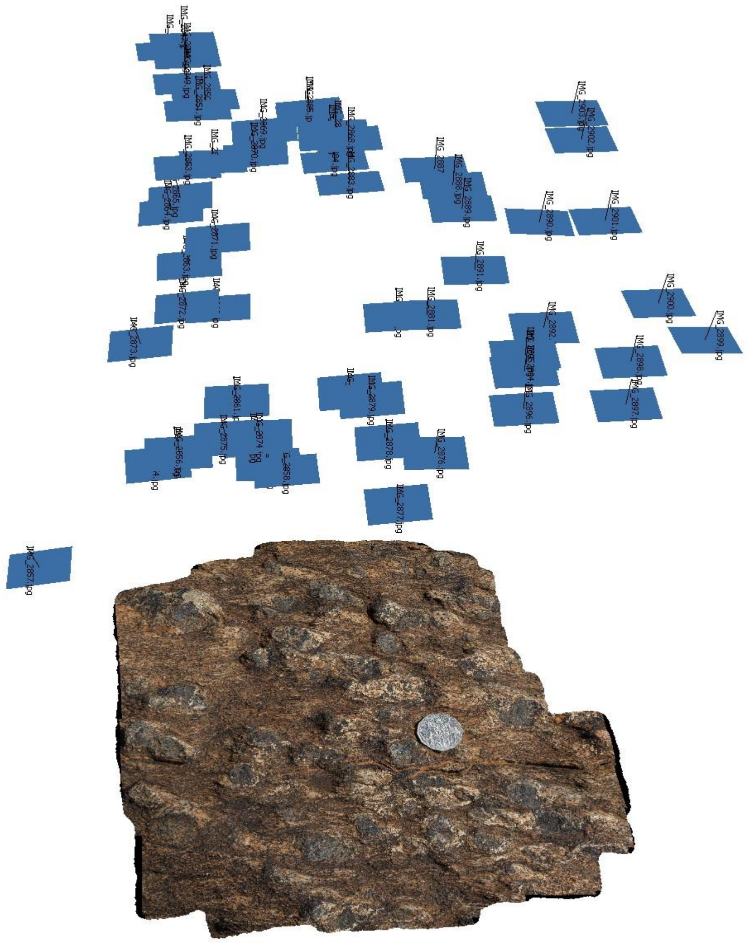
Deep zoom images in this case are best created using digital photogrammetry

Systematically photograph the outcrop making sure that each small section is in focus.

Photogrammetry takes the model geometry into account and allows generation of detailed, in focus orthoimages from any viewpoint



Close-Range Example 1

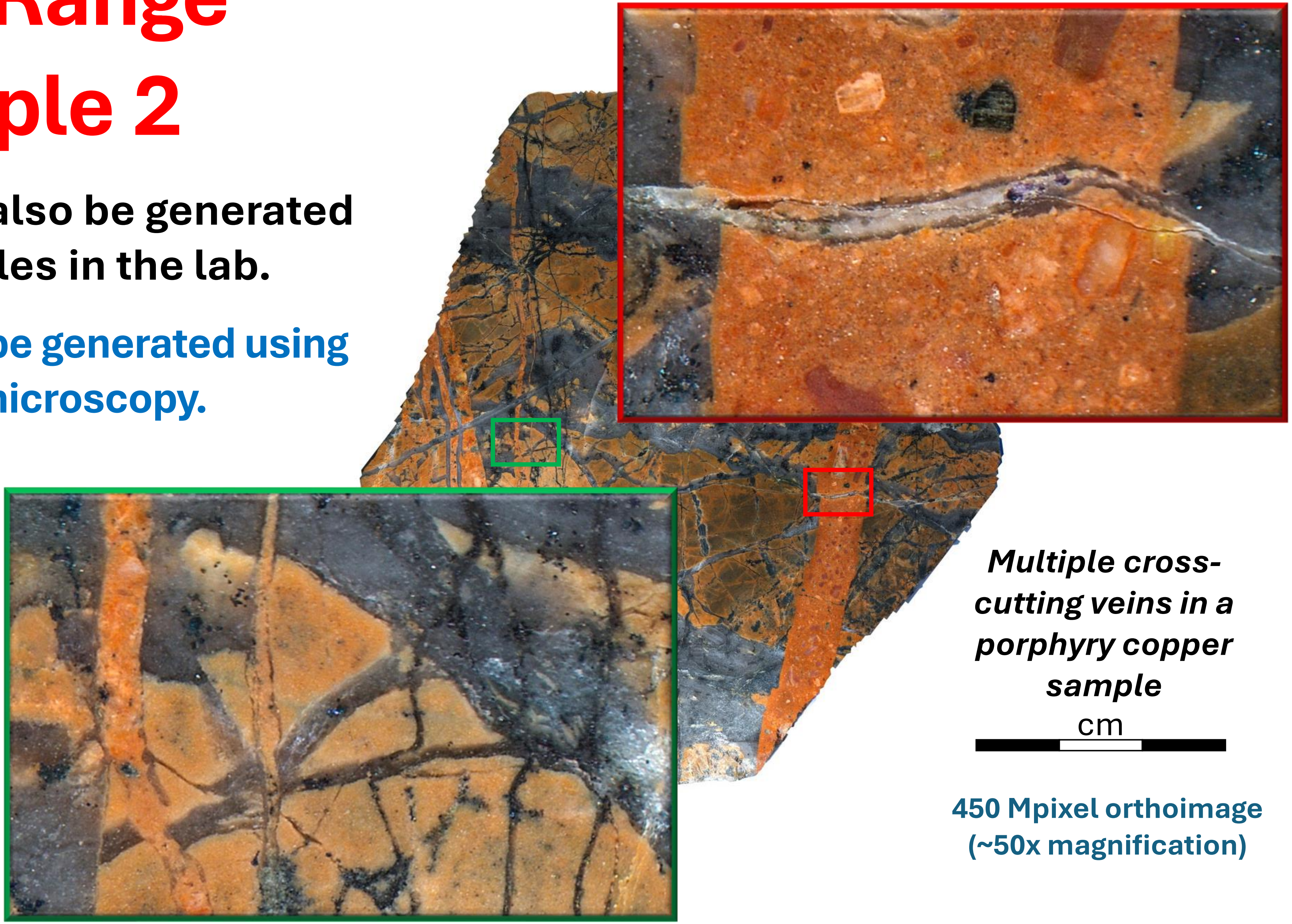


3D Photogrammetric Model

Close-Range Example 2

Orthoimagery can also be generated for small samples in the lab.

Similar images can be generated using automated microscopy.



Multiple cross-cutting veins in a porphyry copper sample

cm

450 Mpixel orthoimage (~50x magnification)

Drone Example

300 Mpixel Orthoimage – Dolphin Mine, pat of north wall

Video

Most static objects such as geological outcrops are effectively depicted using conventional or simple 360 degree imagery.

Dynamic features such as moving machinery or human activity are more effectively depicted with video.

Interviews with mine personnel can add significantly to the experience and realism of a virtual tour.

Dolphin Mine blast – 10% real speed

Slow motion or time-lapse imagery are particularly effective for illustrating many dynamic processes.

Conventional Video

Video is well suited to recording dynamic mining processes such as machinery operation and human activities.

Try to record a full cycle of each activity.

Dolphin Mine – Truck Loading cycle (natural speed and 'time lapse')

It is often useful to speed up imagery to create 'time-lapse' views of long duration activities.

Video Interviews

Mining is not simply about materials and machines.

It is important to capture the human element as well in a virtual tour.

The most effective way to do this is through simple video interviews in which mining personnel explain what they do.

Example video interview – Savage River Mine

It is usually easiest to simply ask questions and record responses.

Cut other video content over the "talking head"

Generally aim for 1 minute final videos for your tour

360 Degree Video

Like 360 degree static images, 360 degree videos capture the entire viewfield.

360 video provides detail of features in motion but also provides context for these processes.

Modern cameras can record up to 8k 360 degree video. However, I have found that current virtual tour production software struggles with 8k.

Record in 8K for archival purposes but process to 6k or 4k for incorporation into tours.

360 Degree Video Example

360 Video of mining operations at Savage River Mine

Time Lapse Video

Waste removal at Savage River Mine

Menus and Information

Effective navigation in virtual tours requires appropriate menus that can guide the user towards particular elements of the tour.

For very simple tours it is possible to embed navigation controls within 360 degree tour elements and within the 'skin' controls.

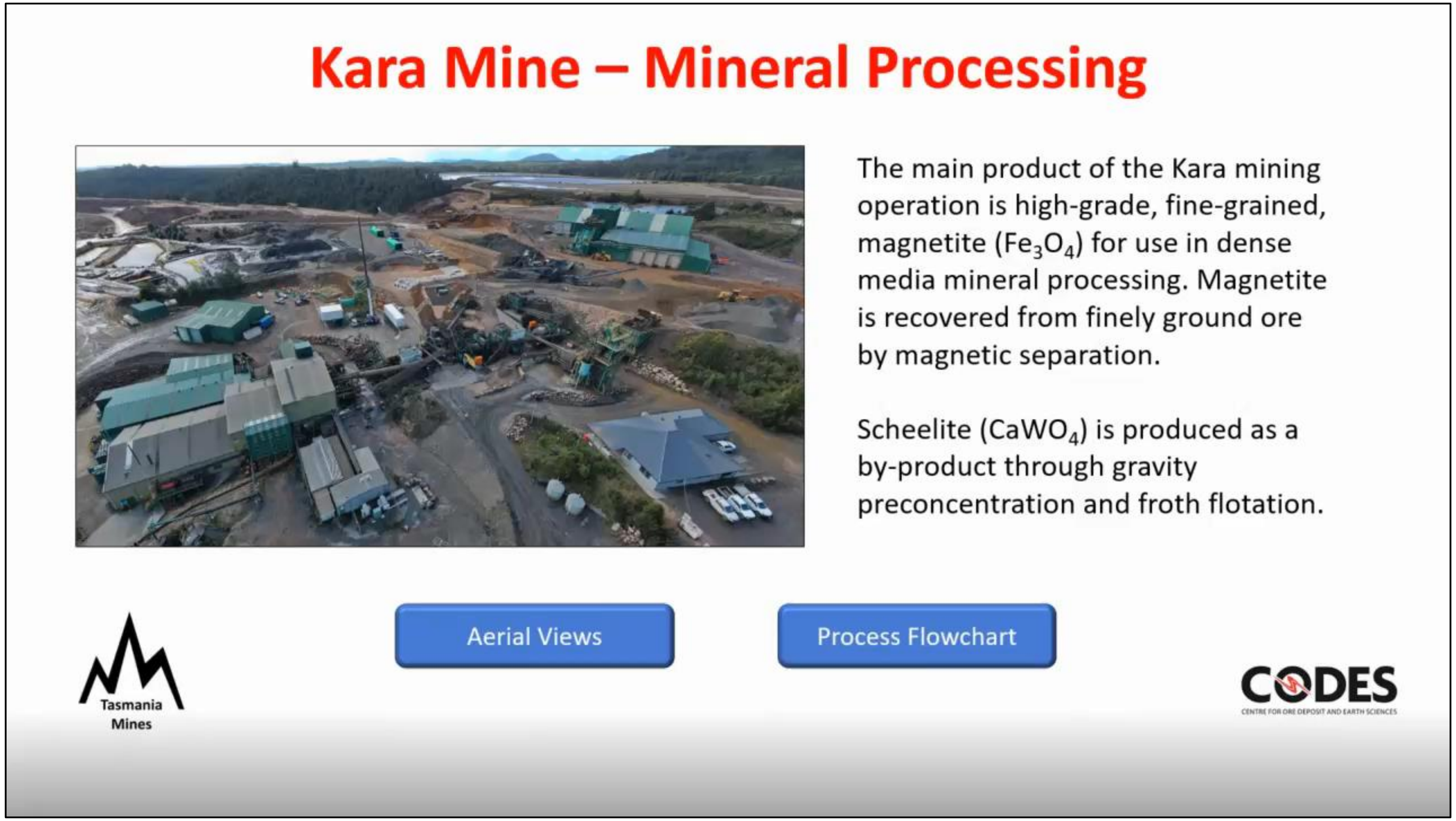
For more complex tours, dedicated menu and information pages may be more appropriate and these need to be produced as image files (jpeg, tiff, png etc).

Menu Production

Any graphics software can be used to generate menu pages (as images)

My approach is to generate a Powerpoint file for each site in which each slide represents a potential menu or information page.

Each page is then output as a separate image file that can be used in Pano2VR.



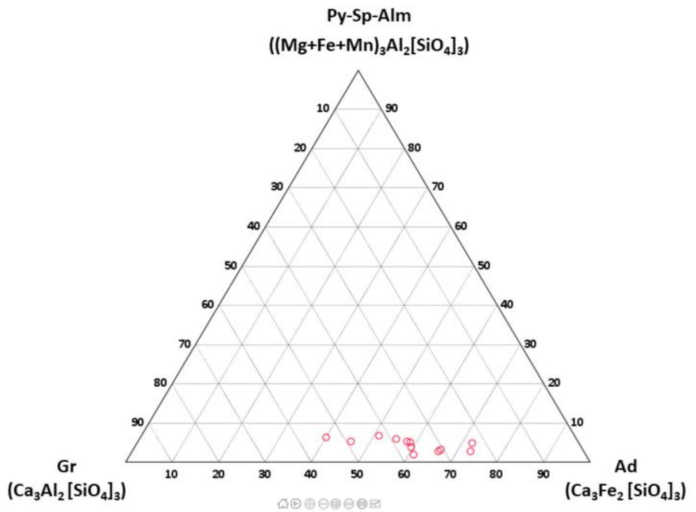
For my tours I use a relatively standardized format with a white background, simple text, images and buttons but any graphic design is possible.

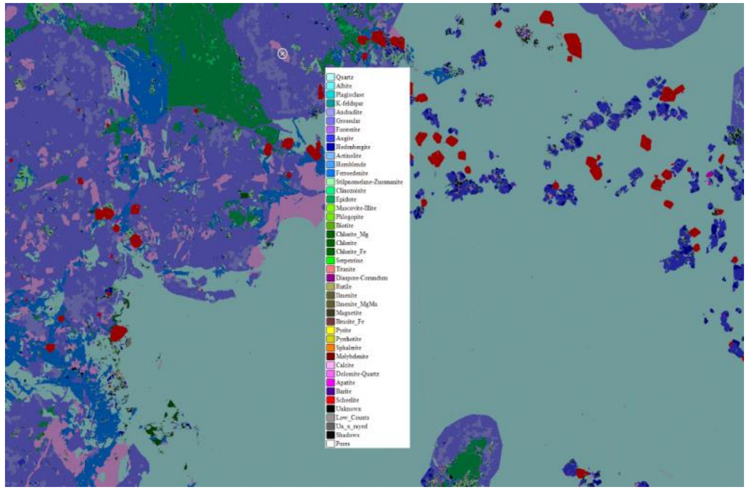
Analytical Data

Like menus, analytic and other numerical data are converted into images

Data can readily be presented as tables, in image form or as graphs.

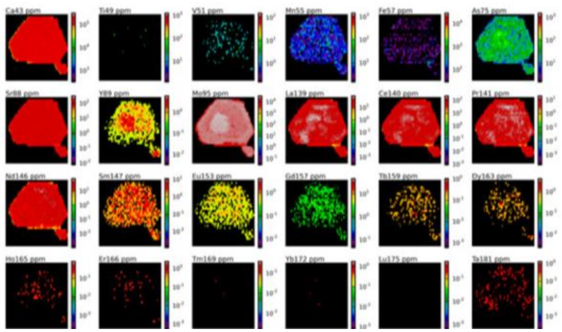
It is possible to link from these graphic features to external data files (.xlsx, .csv etc) that contain the data. These data files are stored separately on the tour server.



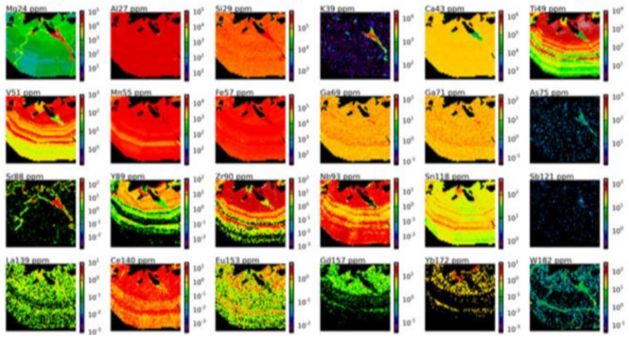


Oxide wt%, detection limit filtered (99% confidence)																			
SiO_2	TiO_2	Al_2O_3	V_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	SrO	BaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	F	O	H_2O	TOTAL
47.68	0.08	3.04	0.07	0.01	30.48	1.34	2.98	11.27	0.02	0.01	0.41	0.16	0.01	0.01	0.03	0.01	0.01	1.90	99.45
42.65	0.20	7.13	0.04	0.01	33.73	1.22	0.70	11.08	0.01	0.01	0.92	0.21	0.01	0.01	0.04	0.01	0.01	1.85	99.78
43.69	0.12	5.66	0.01	0.01	32.96	1.16	0.89	11.21	0.01	0.01	0.64	0.32	0.05	0.01	0.03	0.01	0.01	1.86	98.57
43.17	0.12	7.05	0.01	0.01	32.48	1.02	1.62	11.38	0.01	0.01	0.69	0.48	0.01	0.01	0.04	0.01	-0.01	1.86	99.90
41.56	0.44	8.55	0.01	0.01	33.78	0.75	0.15	11.31	0.01	0.01	0.75	0.53	0.01	0.01	0.12	0.01	-0.02	1.84	99.77
39.20	0.28	10.86	0.06	0.01	32.63	0.89	0.80	11.17	0.01	0.01	1.20	0.89	0.06	0.01	0.13	0.01	-0.04	1.84	99.97
39.99	0.28	10.48	0.05	0.01	32.08	0.90	0.81	11.28	0.01	0.01	1.00	0.63	0.01	0.01	0.10	0.01	-0.02	1.85	99.44
41.83	0.40	7.95	0.06	0.01	33.09	1.00	0.79	11.10	0.01	0.01	0.85	0.61	0.02	0.01	0.10	0.01	-0.03	1.85	99.60
41.07	0.35	8.74	0.05	0.01	32.53	1.04	0.81	10.93	0.02	0.04	0.96	0.70	0.01	0.01	0.13	0.01	-0.03	1.85	99.14

Scheelite



Garnet

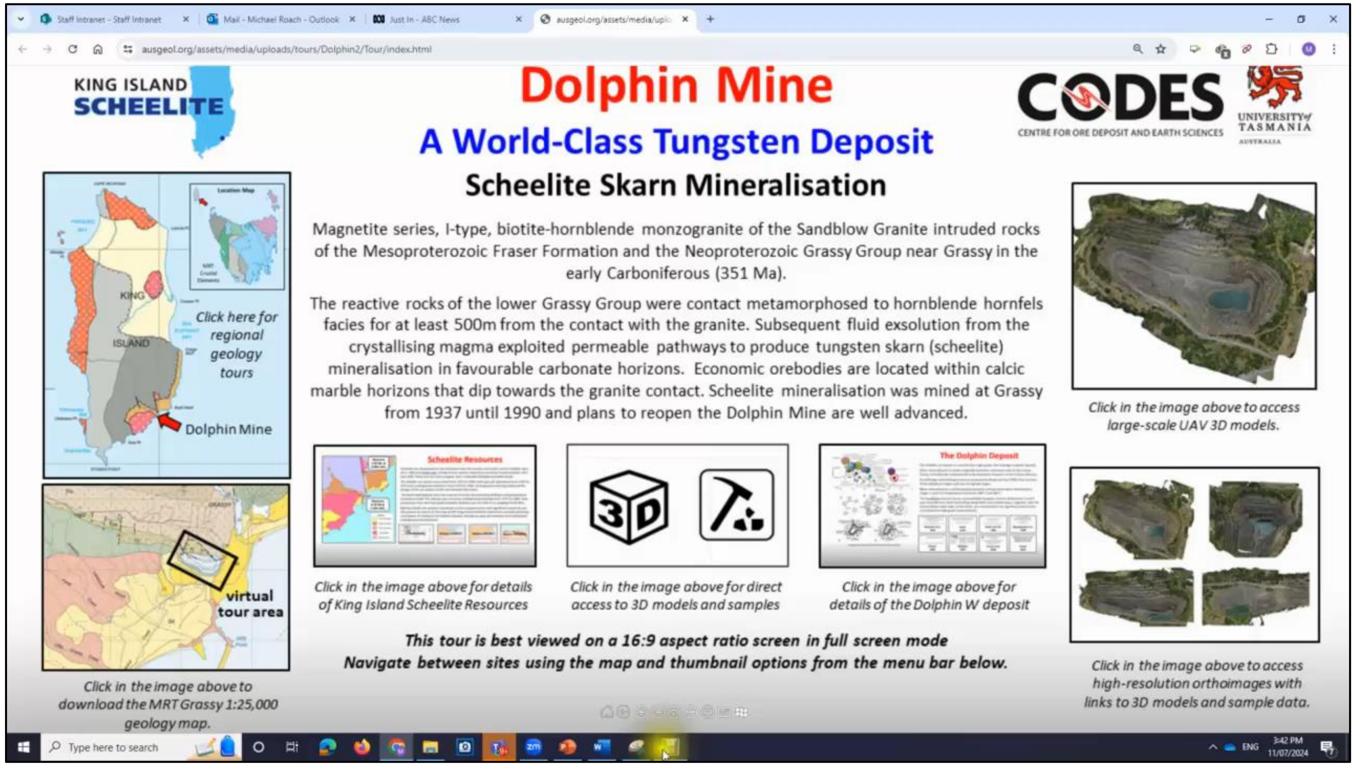


References

For tertiary and professional education it is appropriate to provide links to access peer-reviewed papers or company publications.

Links can be to external primary sources (journals, company reports etc) but web addresses may break and may change over time….

A safer alternative is to download the reference and to store it on the local server to be accessed by the tour.



References may be set up to open within the tour window but it is often more useful to open them in separate browser panes so they can remain open during tour navigation.

Tour Planning

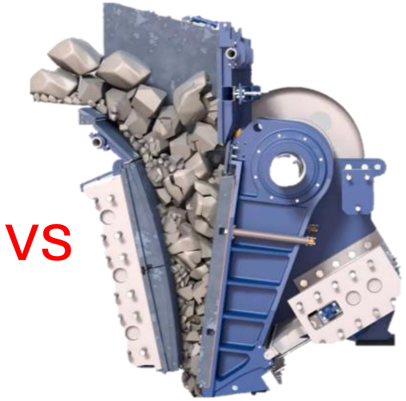
Mine sites are complex environments and, in the limited time available, it is usually not possible to document all aspects of the mining process.

geology

VS

mining

VS



processing

VS

environment

It is important to think carefully about priorities for data acquisition prior to a site visit but be prepared to amend those priorities when on-site – have alternative plans.

Data Density

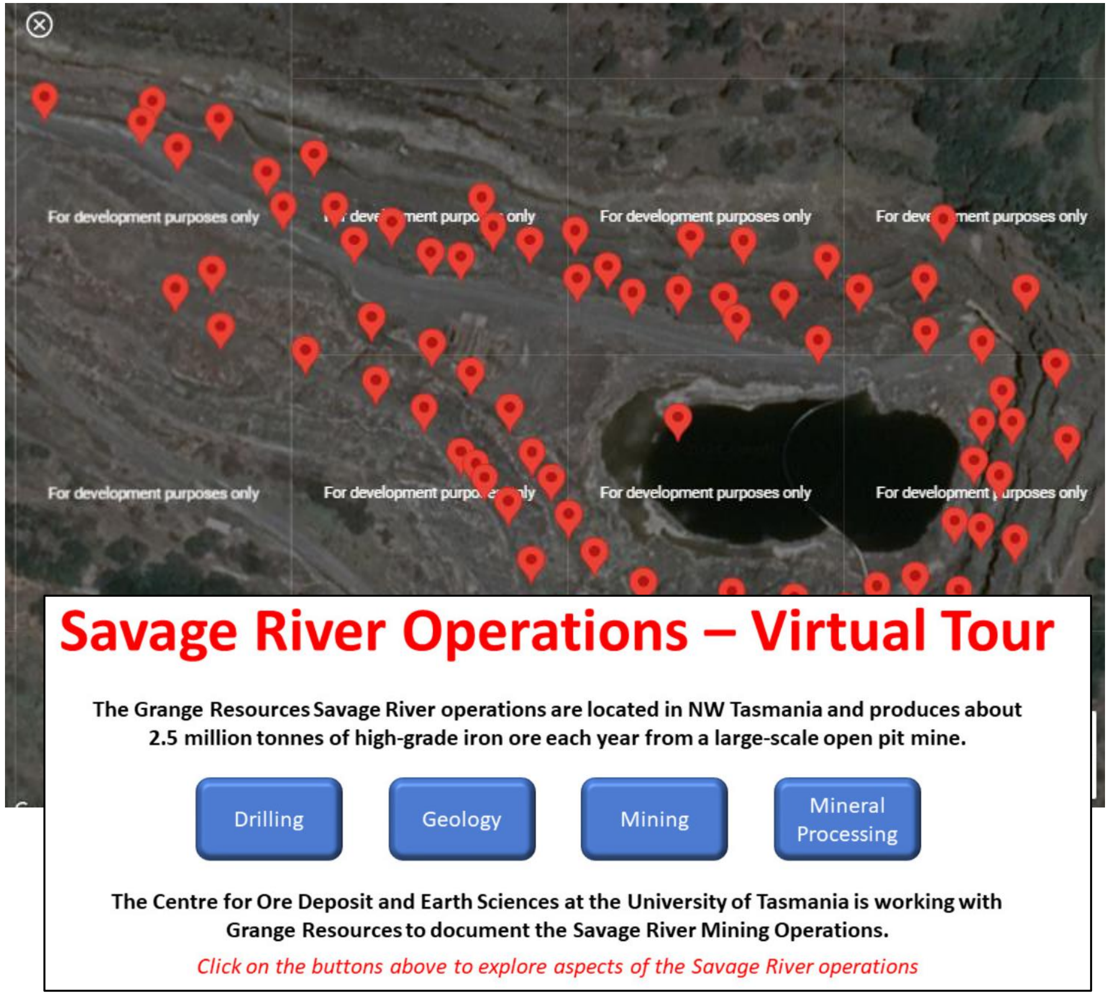
The density of data acquired depends on several factors:

- Aims of the tour
- Time on site
- Cooperation of site staff
- Access limitations
- Process complexity

No simple answer – need to provide enough information and context to make the topic intelligible to the intended audience.

If time is limited - need to identify the most significant features to document.

Too much data and complexity complicates tour production and navigation.



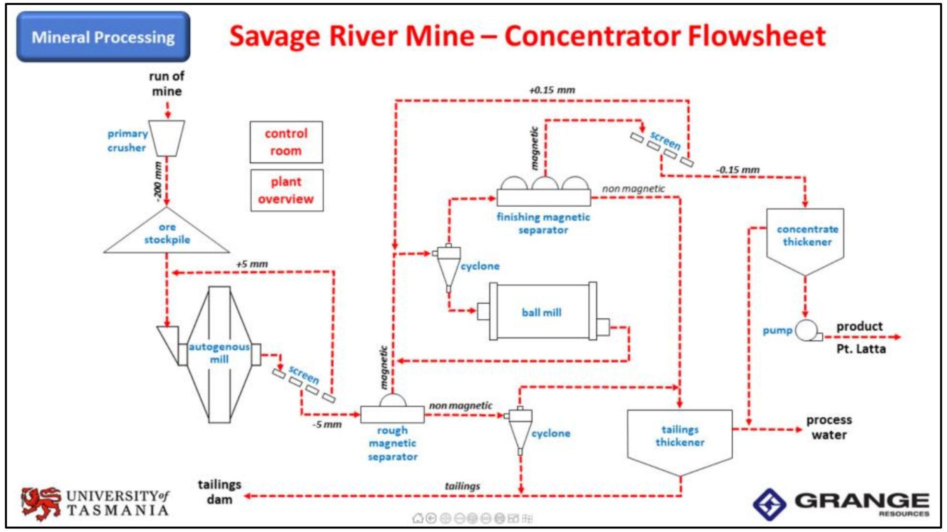
Generally best to create stand alone "sub tours" that document specific aspects of an operation that are linked through an overall site page.

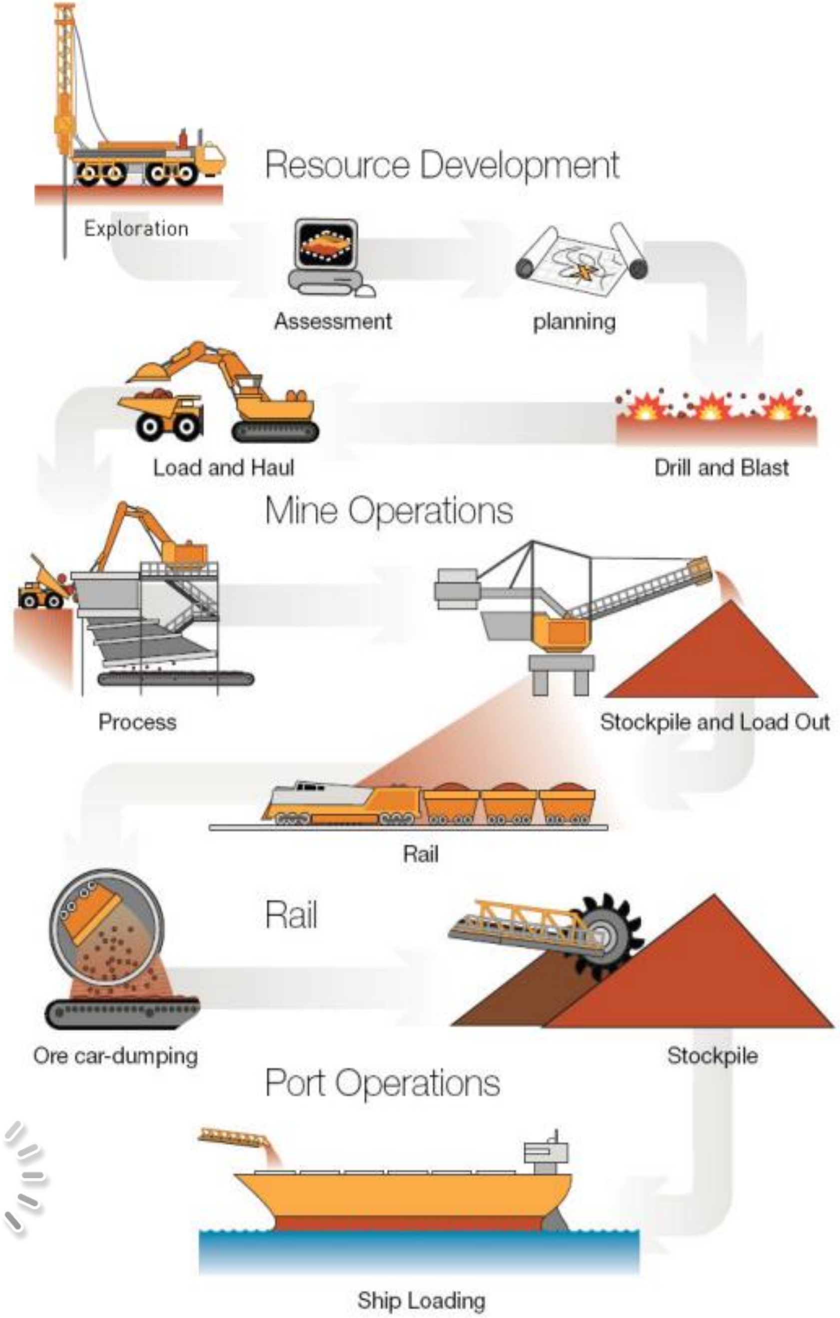
Flow Charts

Mining operations are complex and generally are best depicted using flowcharts.

Flowcharts can be included in tours to provide direct access to selected aspects of an operation or process.

Flowcharts provided by mine operators are usually too complex for use in tours – need to simplify these to emphasize key processes.



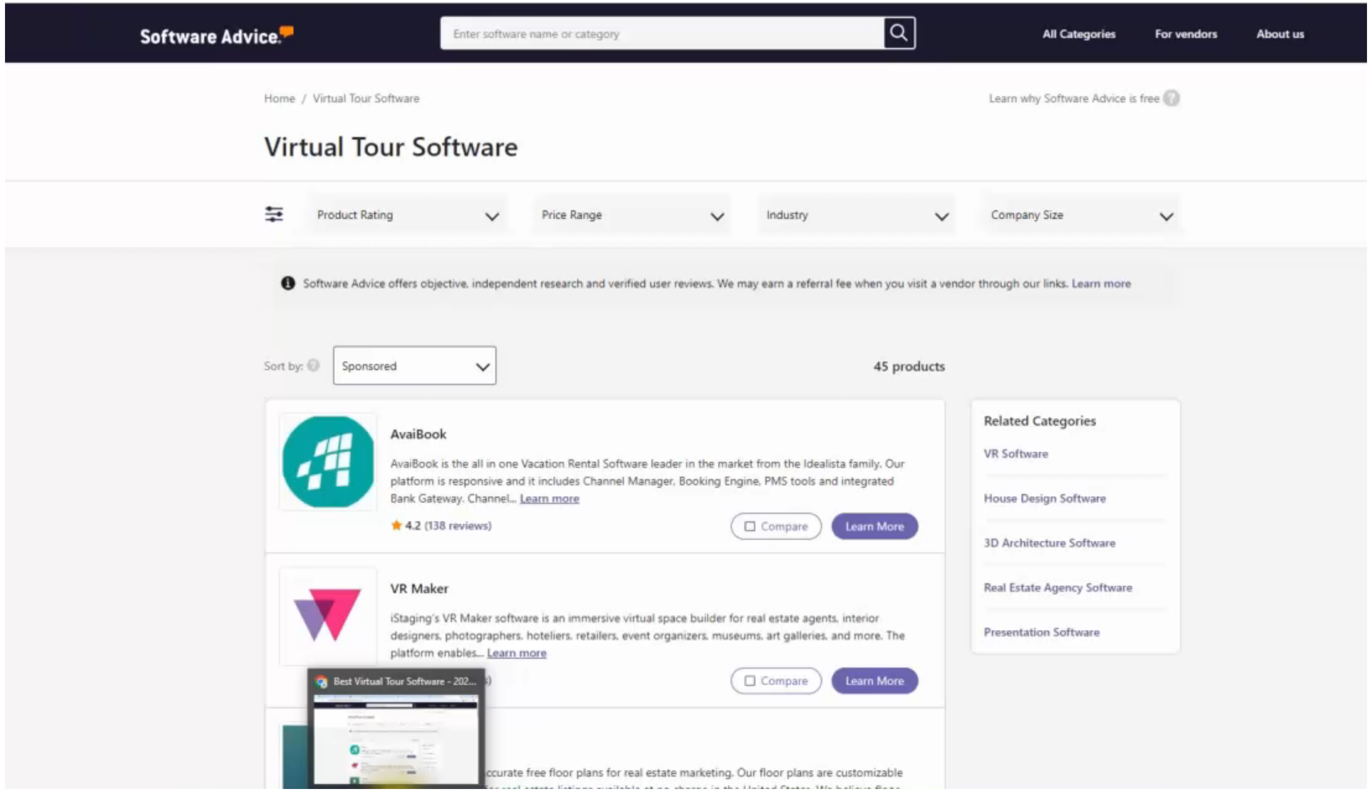


Tour Production

There are many software systems for virtual tour production.

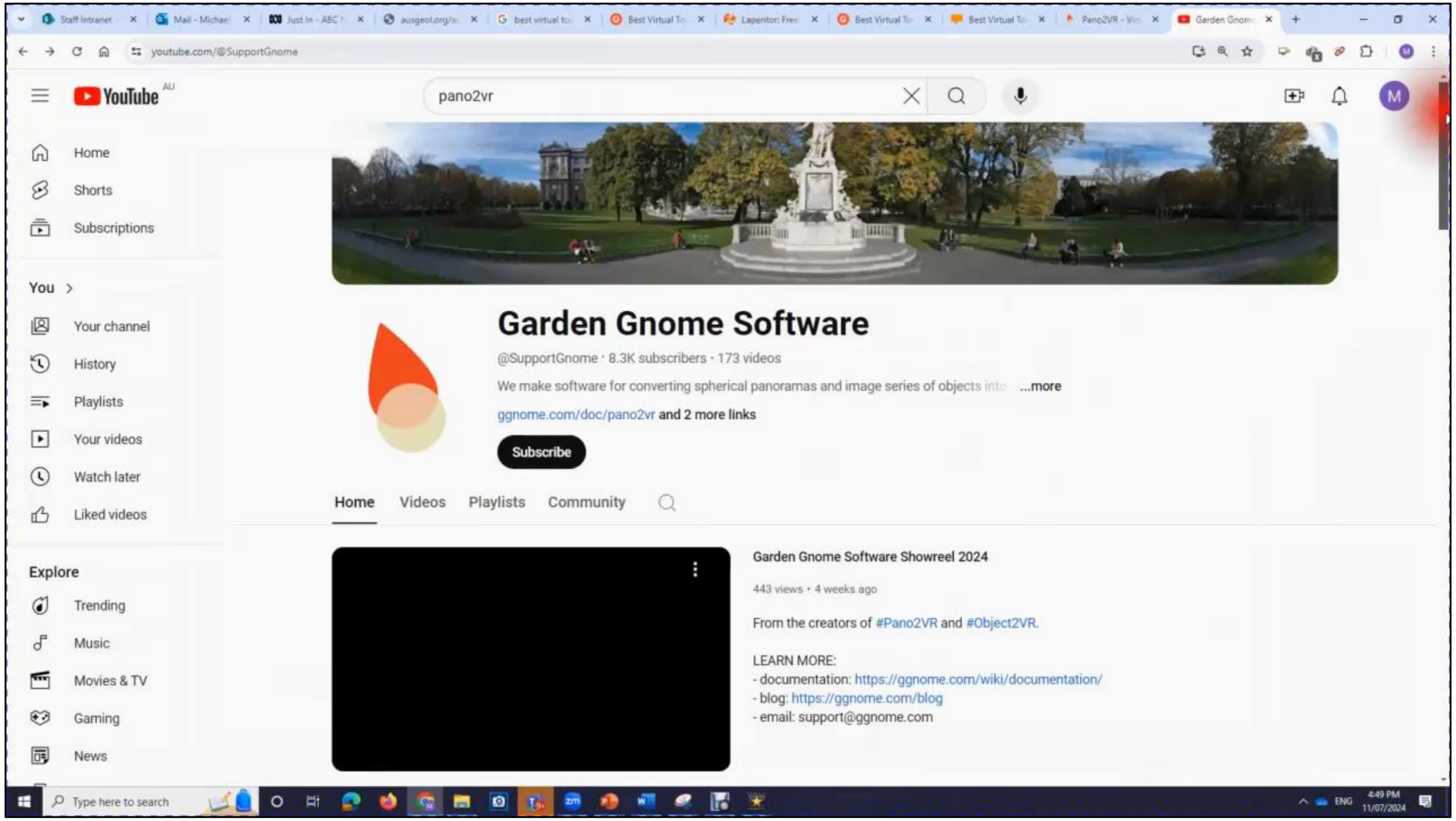
Some virtual tour software are web-based and store and deliver tours from their own servers. These usually require monthly fees and fees for usage of tours.

Other systems produce ‘stand alone’ tours that can then be installed on any selected server for delivery over a web browser.



For the IMMERSE project I have recommended that we use Pano2VR which has a one-off cost and which produces stand-alone tours that can also be deployed to Oculus headsets.

Pano2VR



Detailed [Pano2VR tutorials](), produced by the software providers are available on YouTube.

[Pano2VR]() is virtual tour production software.

Pano2VR can be used to produce immersive tours that can be easily deployed to existing web sites and viewed through web browsers on computers, smartphones and in VR devices.

The following topics provide a very basic introduction to Pano2VR.

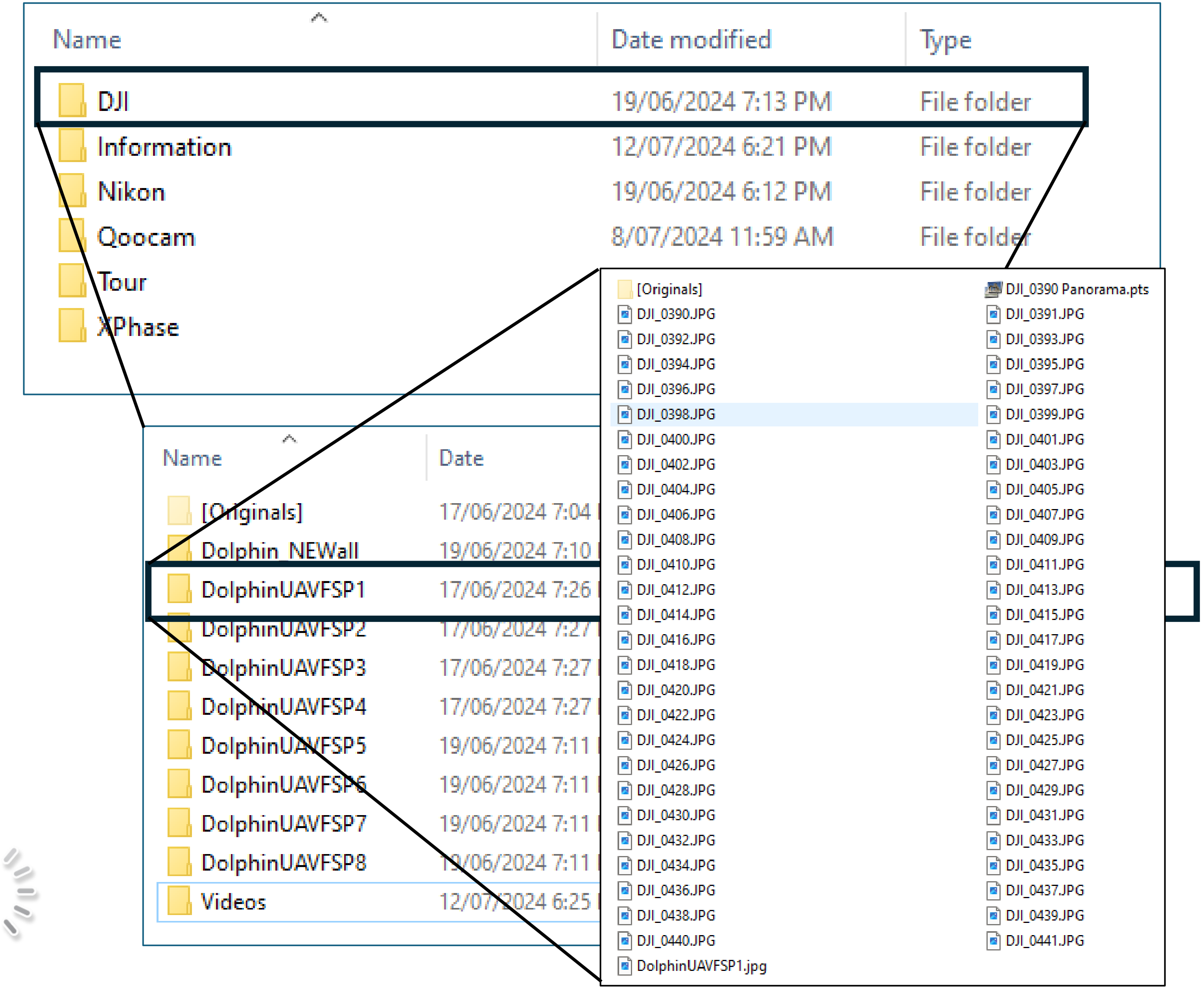
Data Management

Typical virtual tours require collection of 10s to 100s of Gb of data .

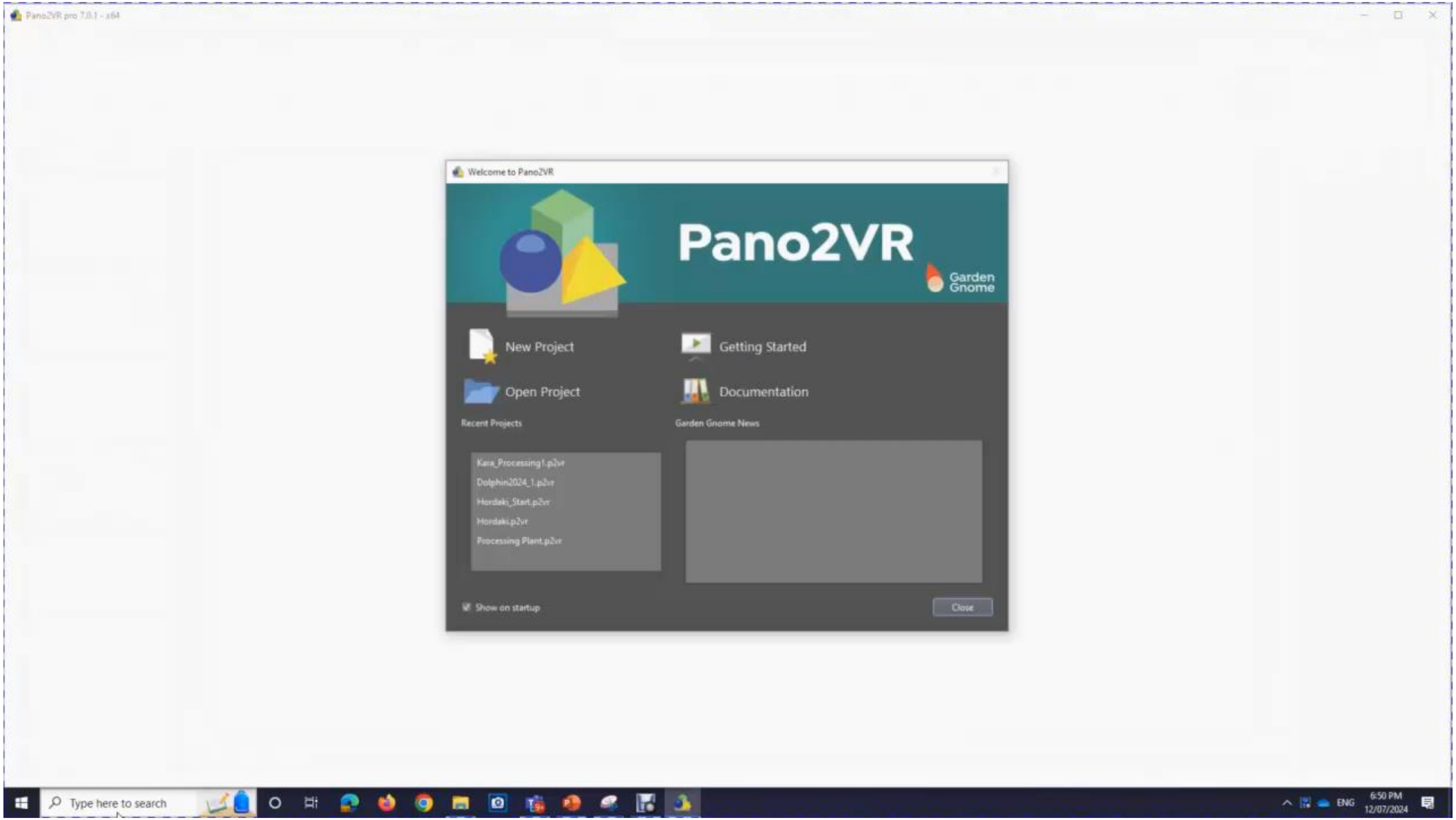
Efficient data management is essential.

For each site I create a series of ‘standard’ folders initially based on data acquisition hardware.

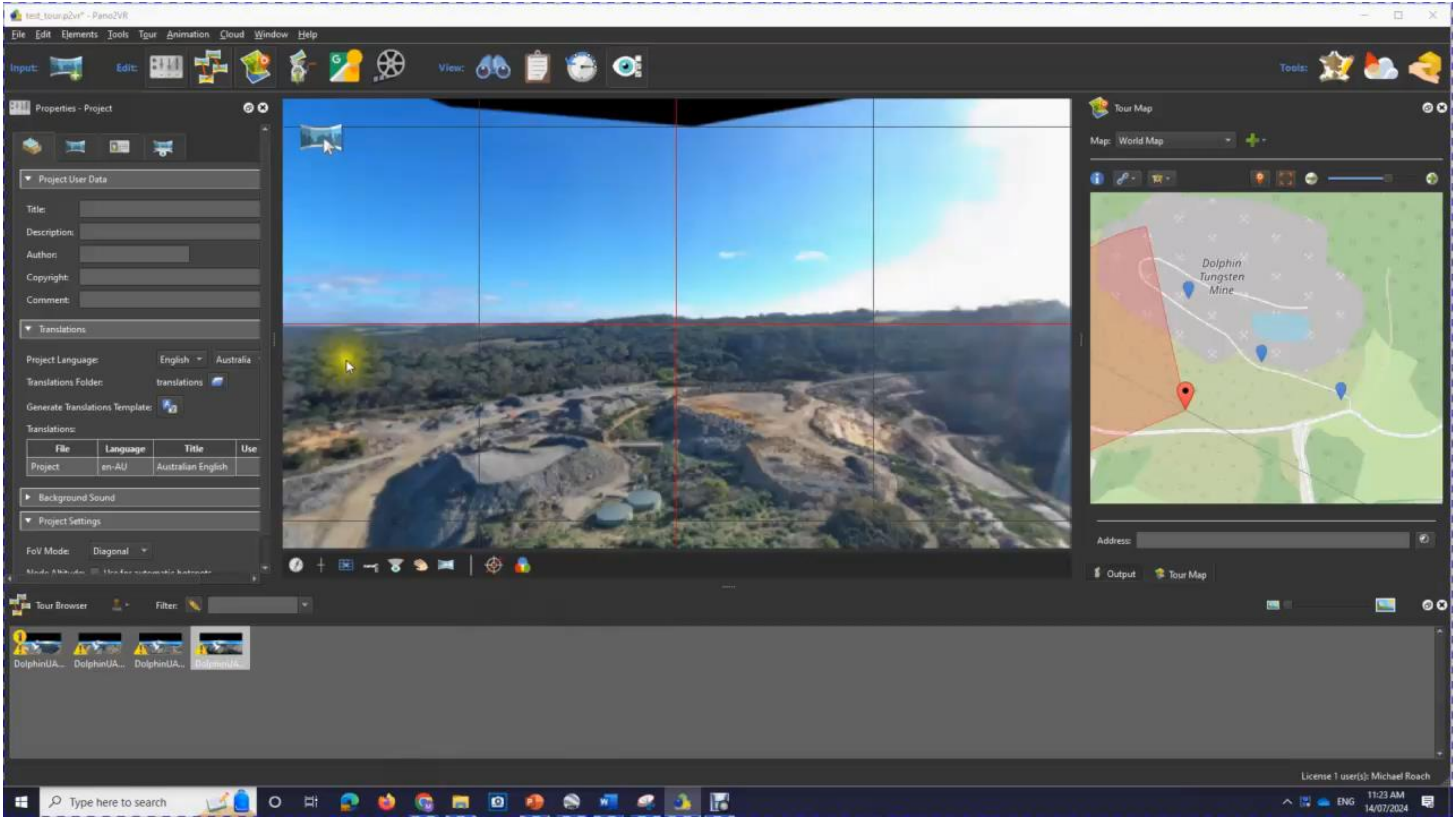
Groups of images or videos related to specific objects are sorted into separate folders.



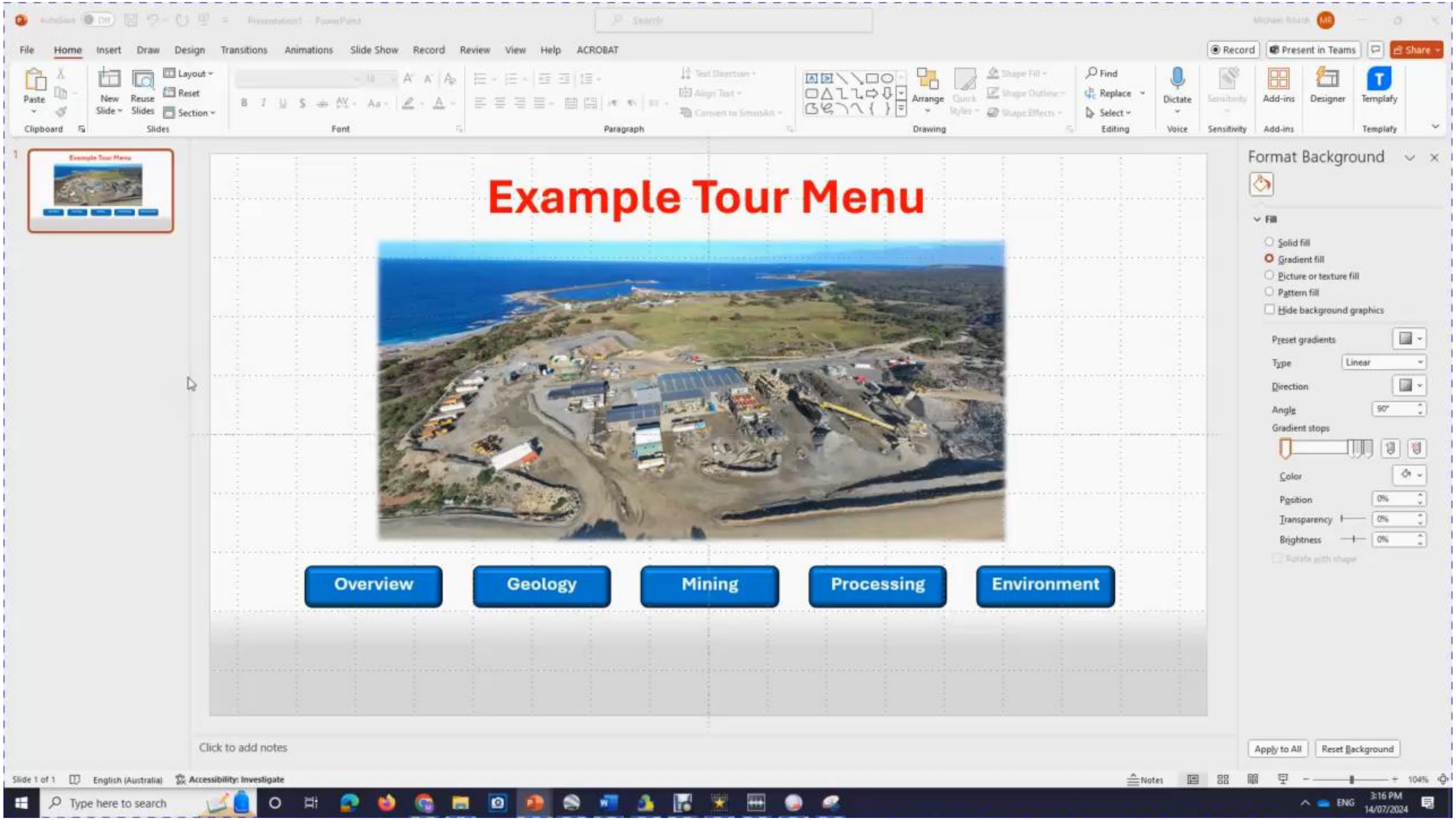
Pano2VR – Load and Orient Imagery



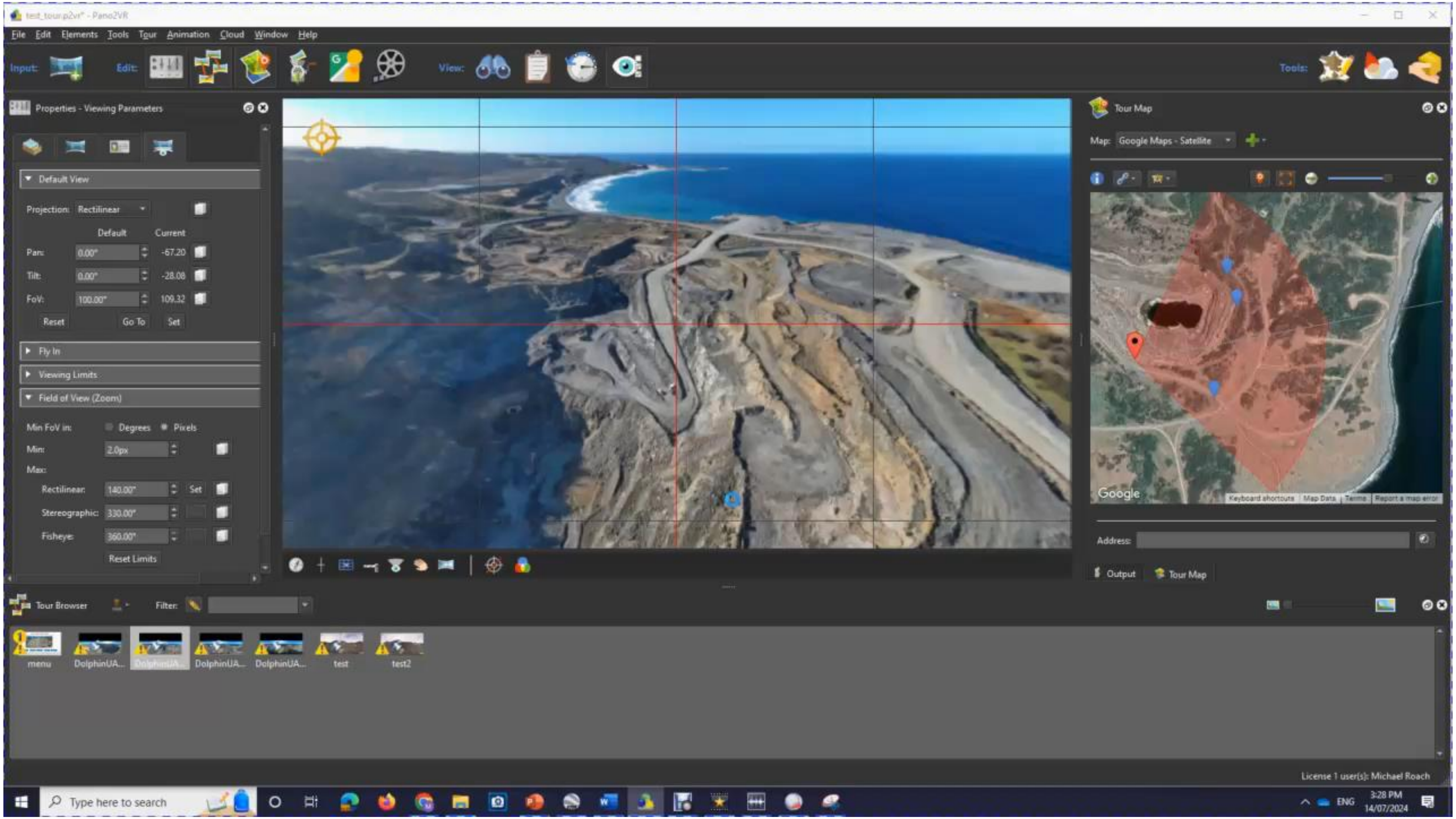
Pano2VR – Image Georeferencing



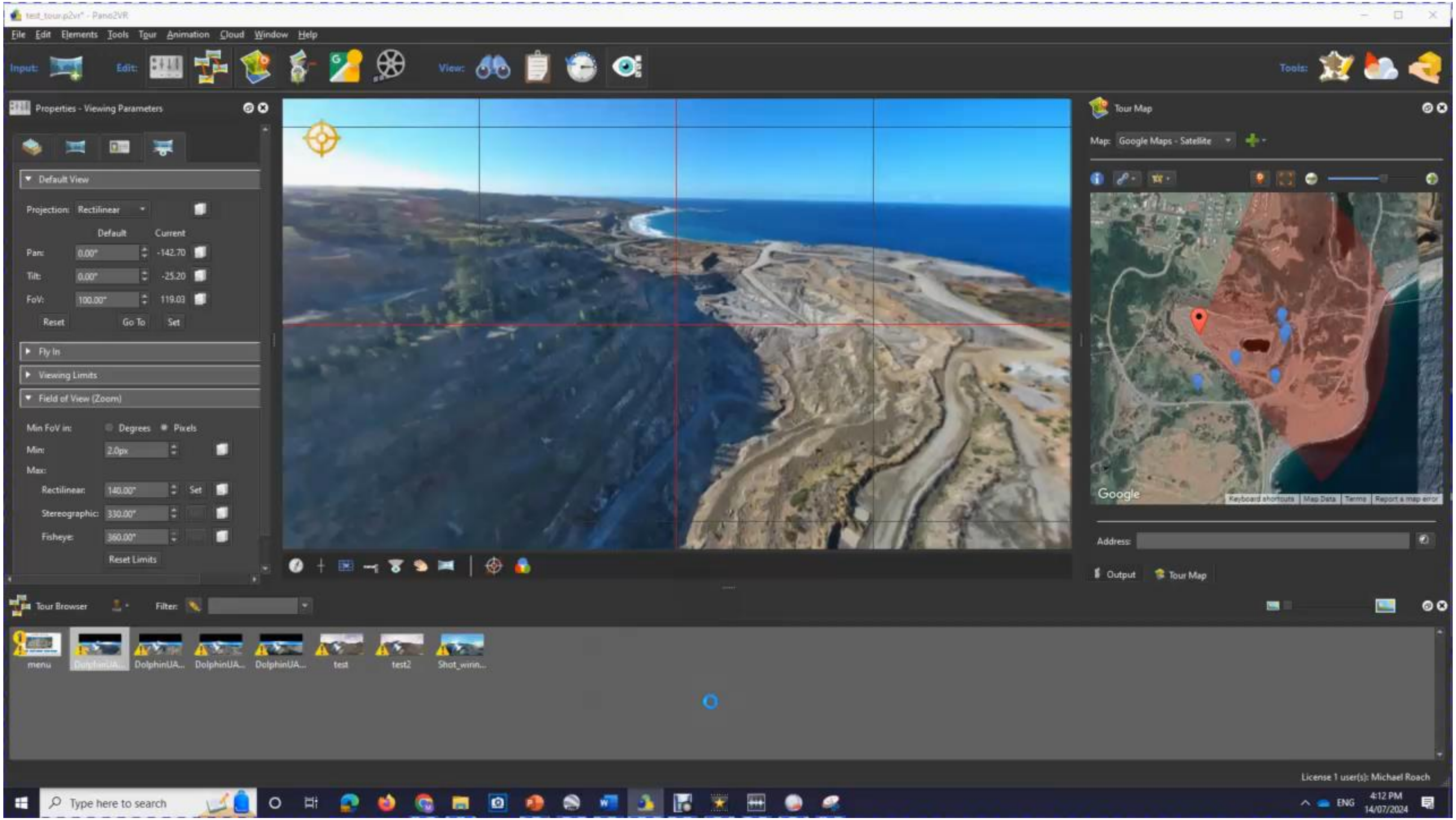
Pano2VR – Adding Menus



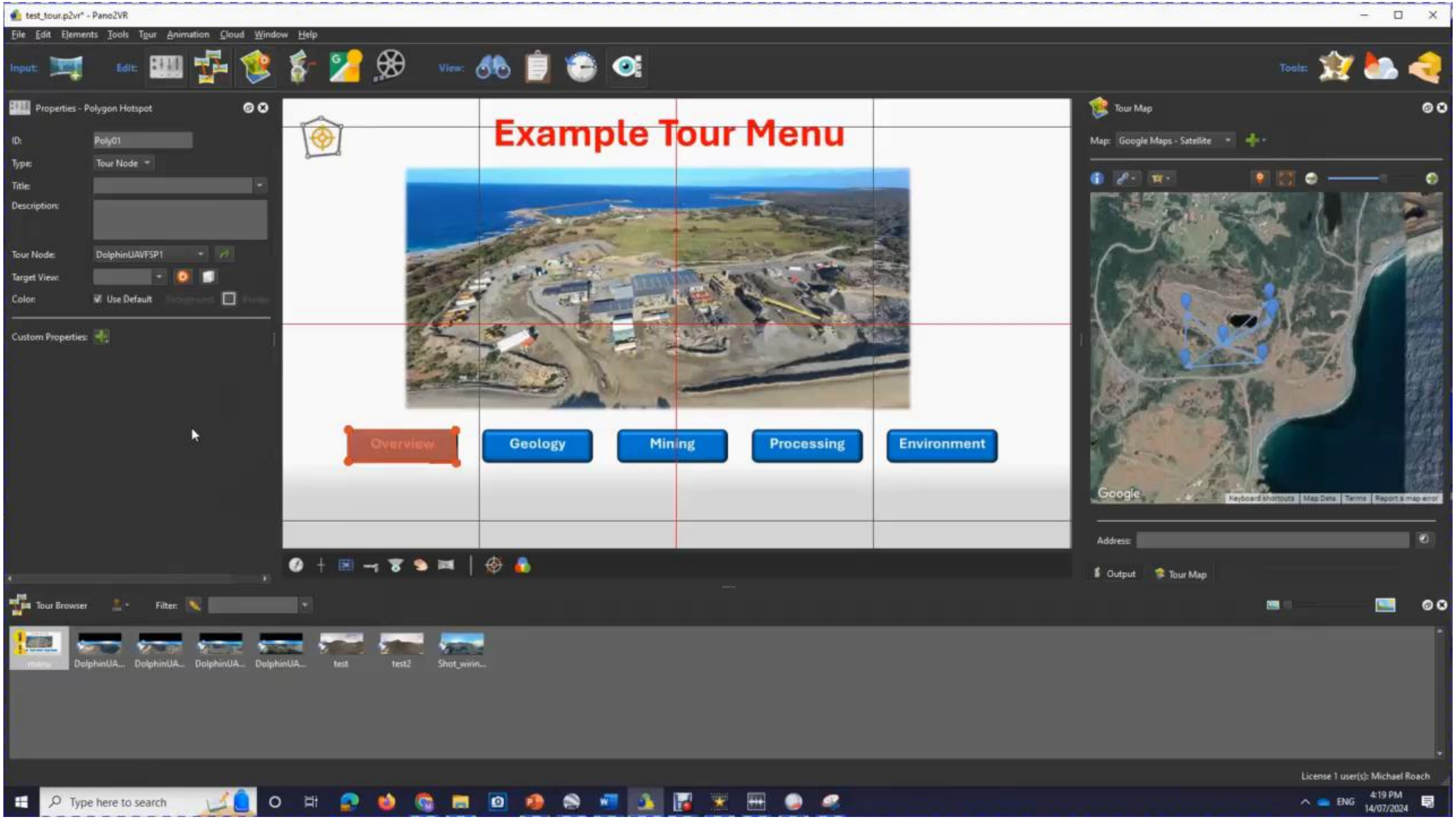
Pano2VR – Adding 360 Video



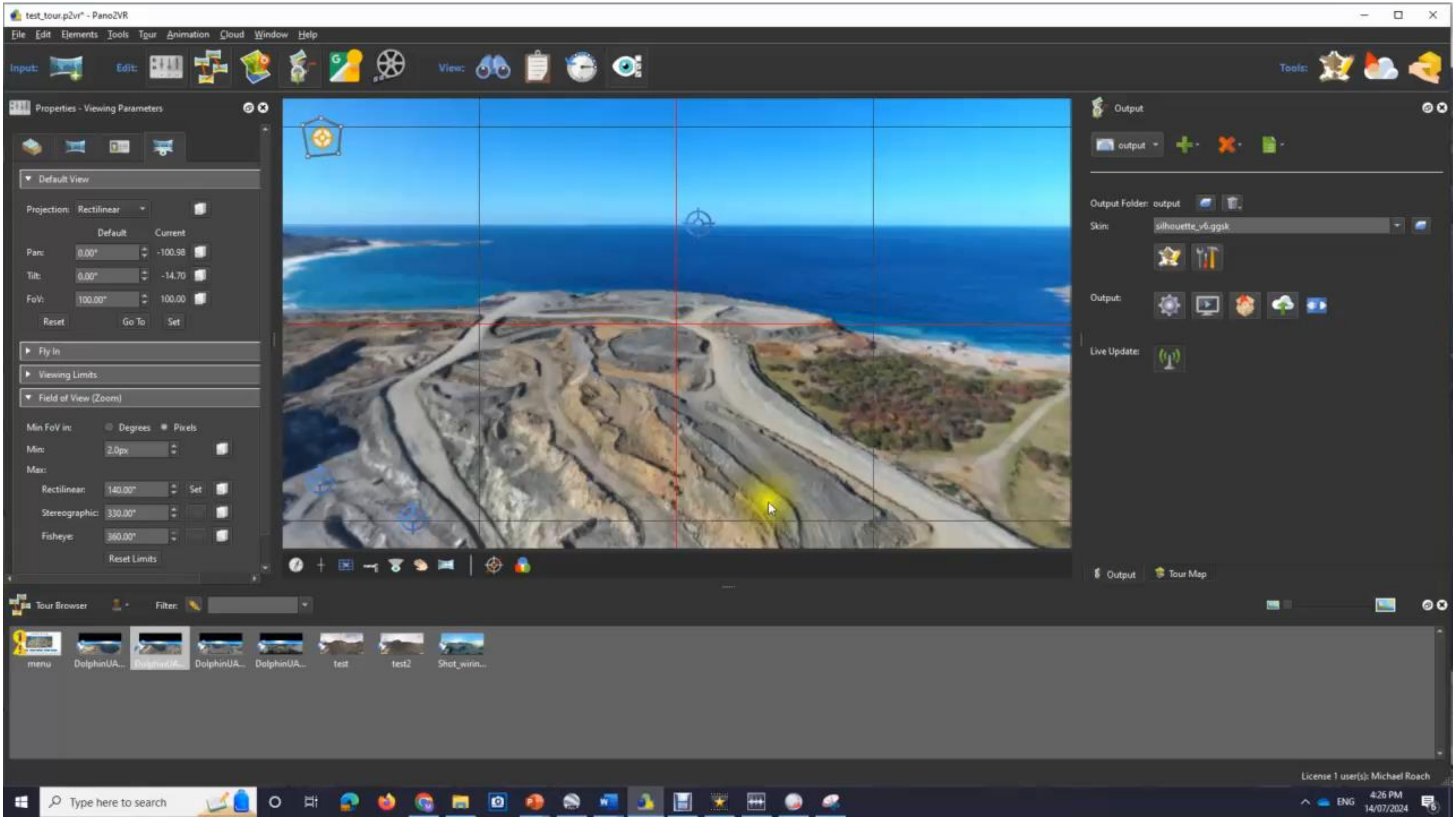
Pano2VR – Adding Links



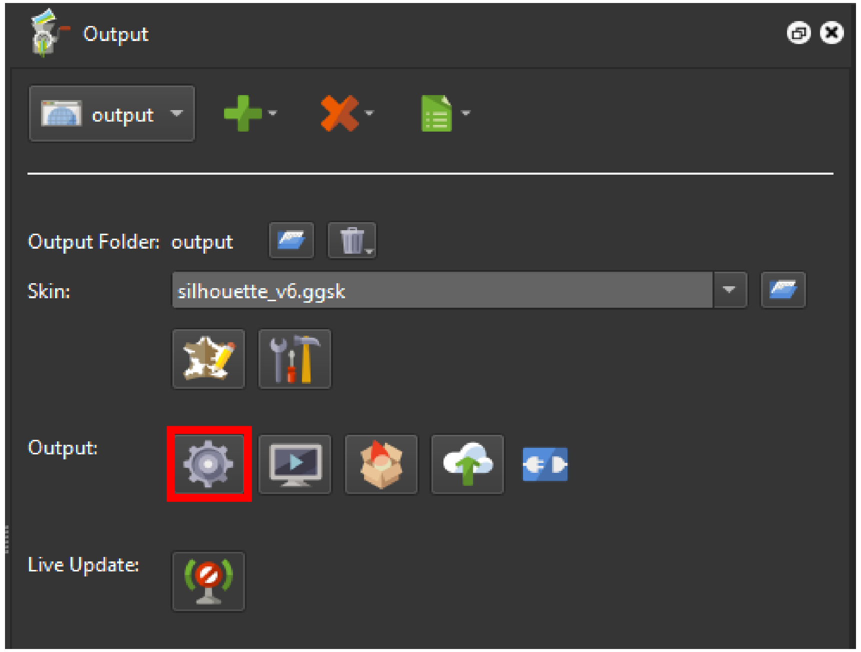
Pano2VR – Process Tour



Pano2VR – Add Components



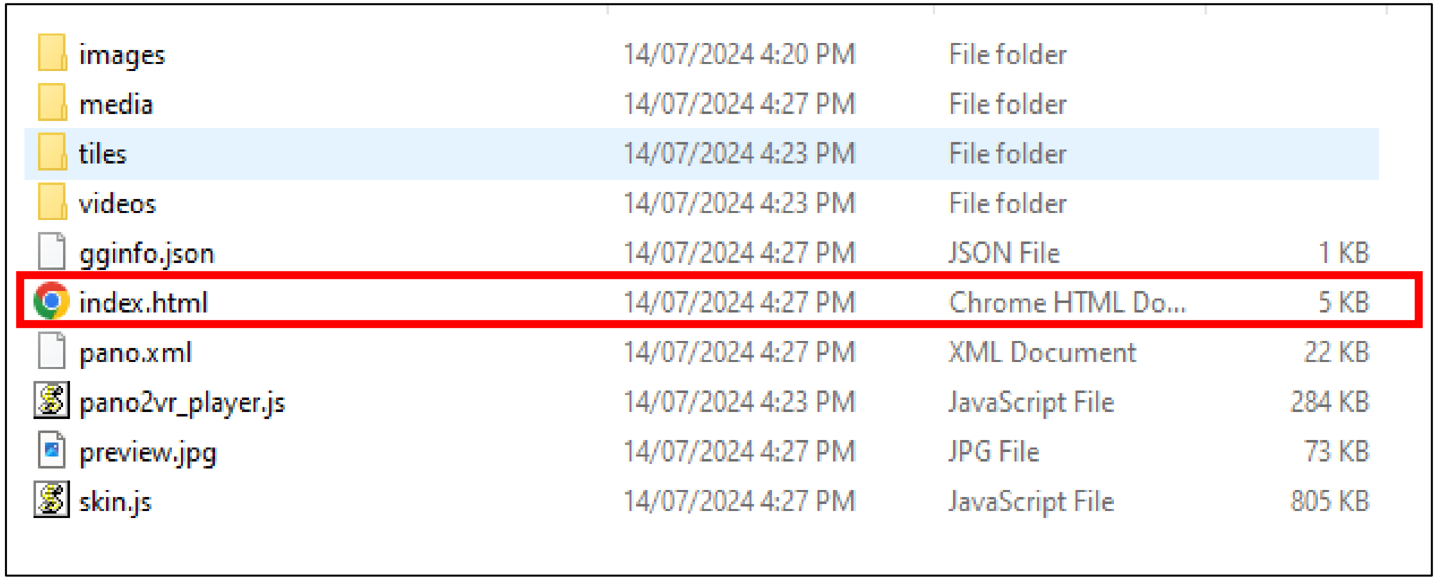
Pano2VR – Web Output



Pano2VR output generates all the files required for web delivery.

These files can only run from a web server.

Pano2VR uses server emulation to preview tours.



images	14/07/2024 4:20 PM	File folder	
media	14/07/2024 4:27 PM	File folder	
tiles	14/07/2024 4:23 PM	File folder	
videos	14/07/2024 4:23 PM	File folder	
gginfo.json	14/07/2024 4:27 PM	JSON File	1 KB
index.html	14/07/2024 4:27 PM	Chrome HTML Do...	5 KB
pano.xml	14/07/2024 4:27 PM	XML Document	22 KB
pano2vr_player.js	14/07/2024 4:23 PM	JavaScript File	284 KB
preview.jpg	14/07/2024 4:27 PM	JPG File	73 KB
skin.js	14/07/2024 4:27 PM	JavaScript File	805 KB

All resources for the tour are contained in the output folder.

Simply copy this file structure to your web server and hyperlink to the index.html file.

http://www.ausgeol.org/assets/media/uploads/tours/test/index.html