# Geological Visualisation Methods

## A Workshop for Field Geologists


**Michael Roach**

**School of Physical Sciences,**
**University of Tasmania**


UNIVERSITY of TASMANIA

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# Rationale


**Fieldwork is a cornerstone of geological education**

**But… issues of distance, time, cost, access and OH&S mean that new methods are needed to augment (but not replace) field-based education.**

**Conventional photography is inadequate for several reasons……**

# 3D Information

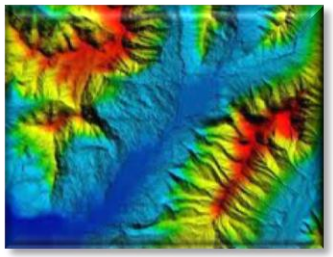
**Interpretation of 3D features from conventional photos is a difficult cognitive task for many students even if multiple photographs are available from different viewpoints.**

**Need to be able to depict the geometry of an outcrop not just the images……**

**Use photogrammetric methods**

# Digital Photogrammetry Process

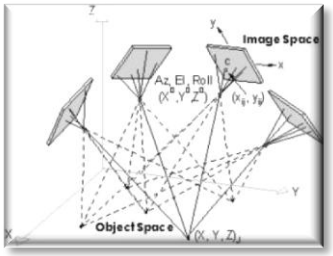
**Reprojection**
orthophoto



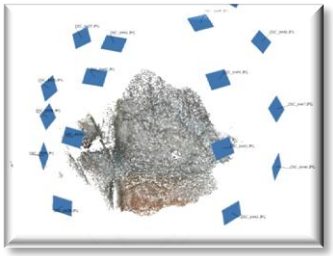
**Interpolation**
DEM


**Image Capture**
digital camera

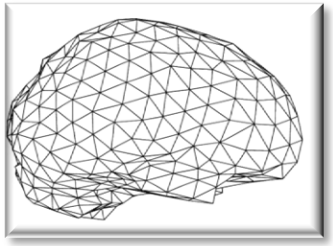
**Feature Selection**
SIFT Algorithm




**Bundle Adjustment**
Interior and exterior



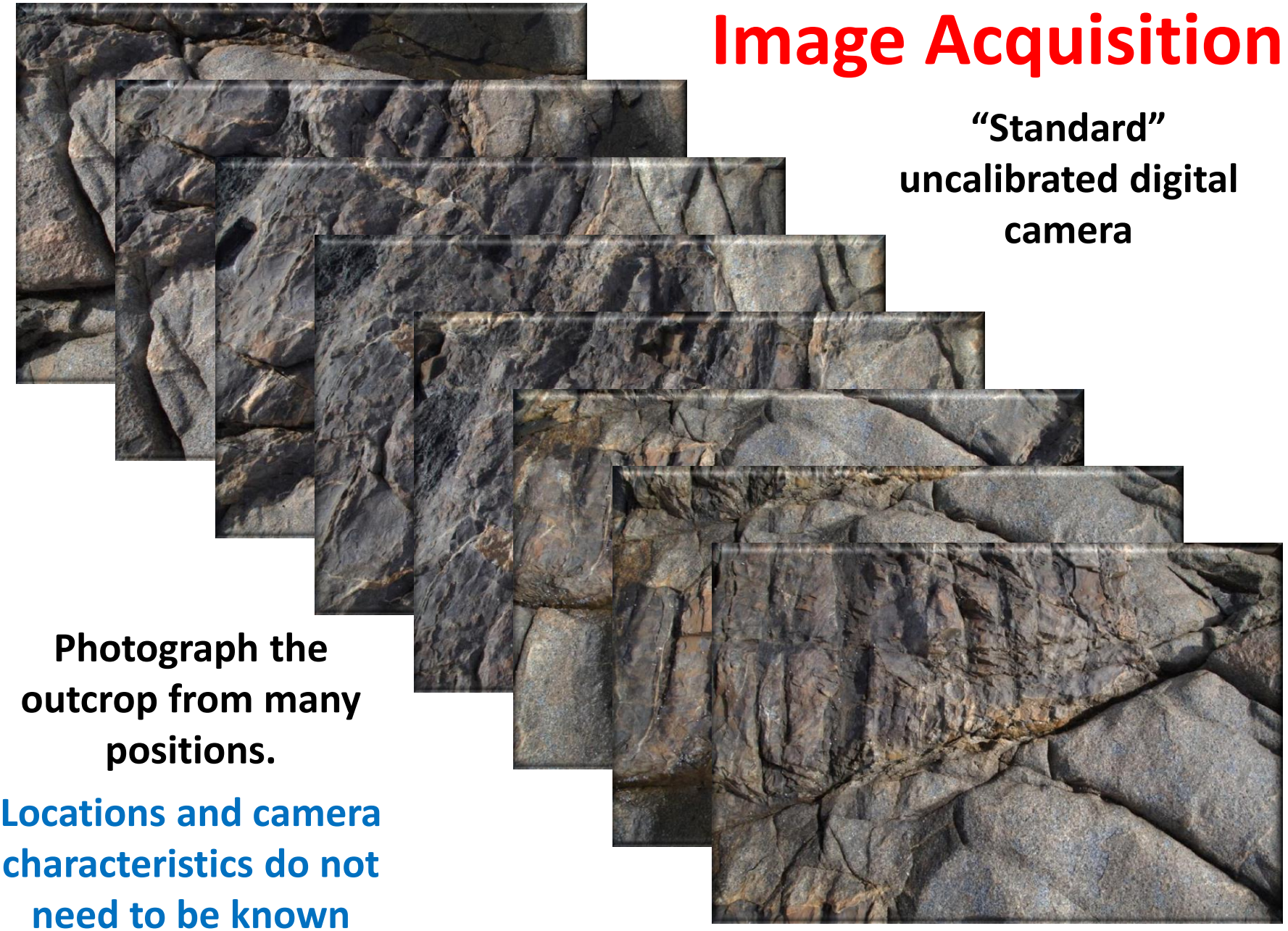
**Geometry Infill**
dense point cloud



**Mesh Generation**
3D model

**Texture Mapping**
photo-realistic model

# Image Acquisition



**"Standard" uncalibrated digital camera**

**Photograph the outcrop 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

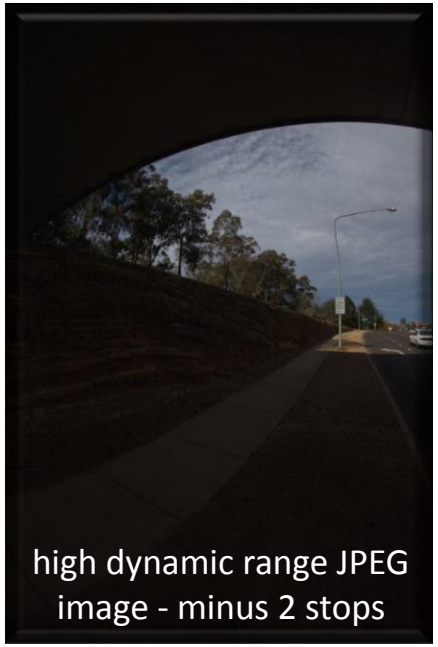
**If your camera allows, best to shoot in RAW**

**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**

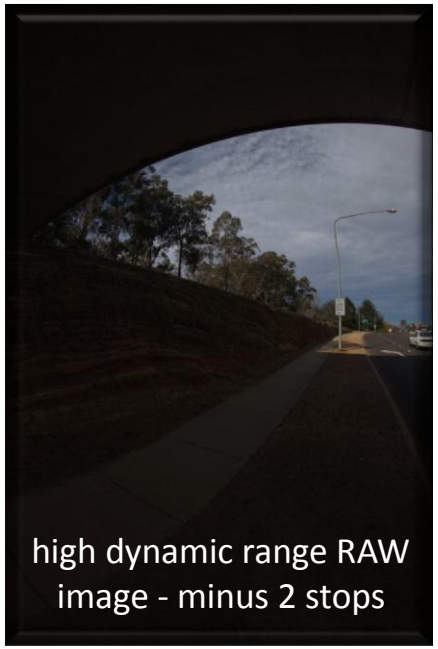
**RAW files : non-lossy compression 14 bits (16384 shades) per colour per pixel**

**Post processing exposure and balance control**

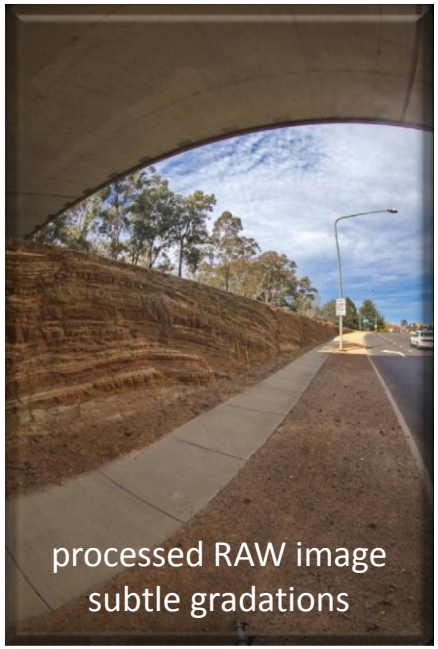


high dynamic range JPEG image - minus 2 stops

processed JPEG image image quantisation



high dynamic range RAW image - minus 2 stops



processed RAW image subtle gradations

# Image 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.

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

Set the balance for JPEG shooting!

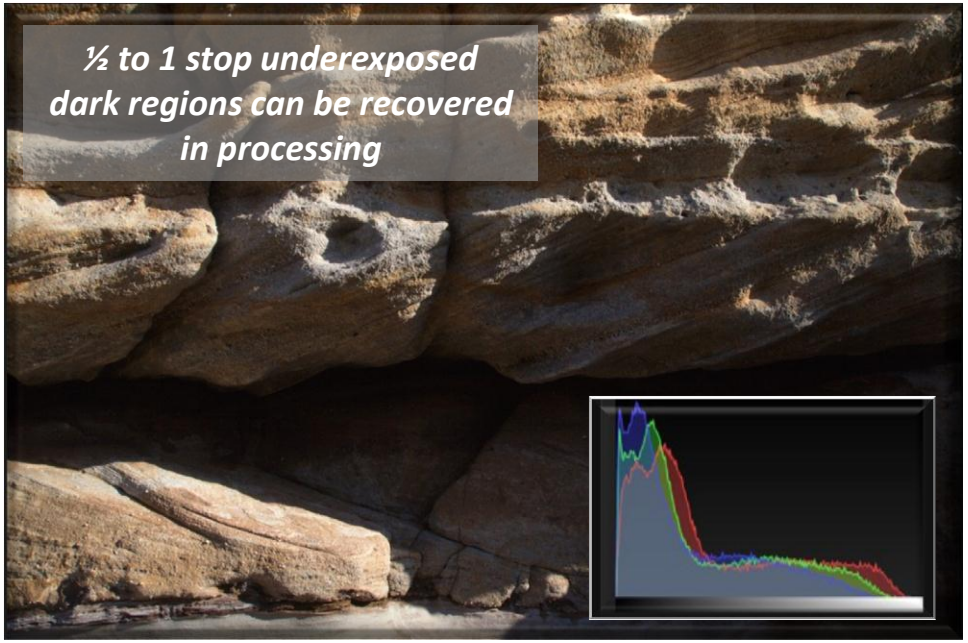
# Exposure

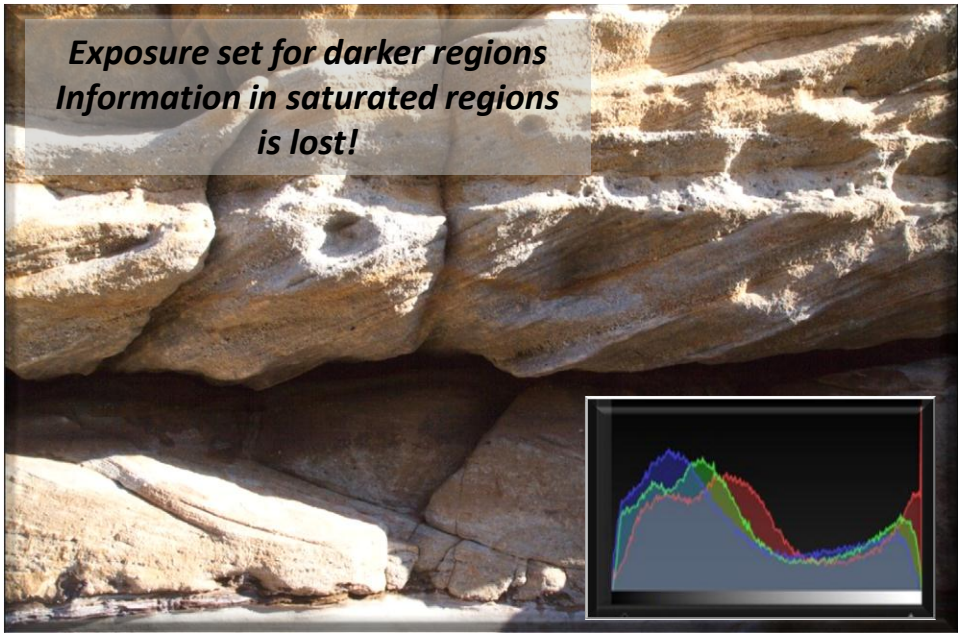
**In uniform lighting conditions automatic exposure is OK but if there are major contrasts then manual exposure is better.**

**Explore the outcrop 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 underexposed but this can usually be recovered in processing (particularly with RAW images)**



# Depth of Field

**Always shoot to maximise 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 1/60 sec to avoid motion blur.**

**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.**

**It is generally best to come in close and use a wide angle lense (~24mm 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.**

# How Many Images??

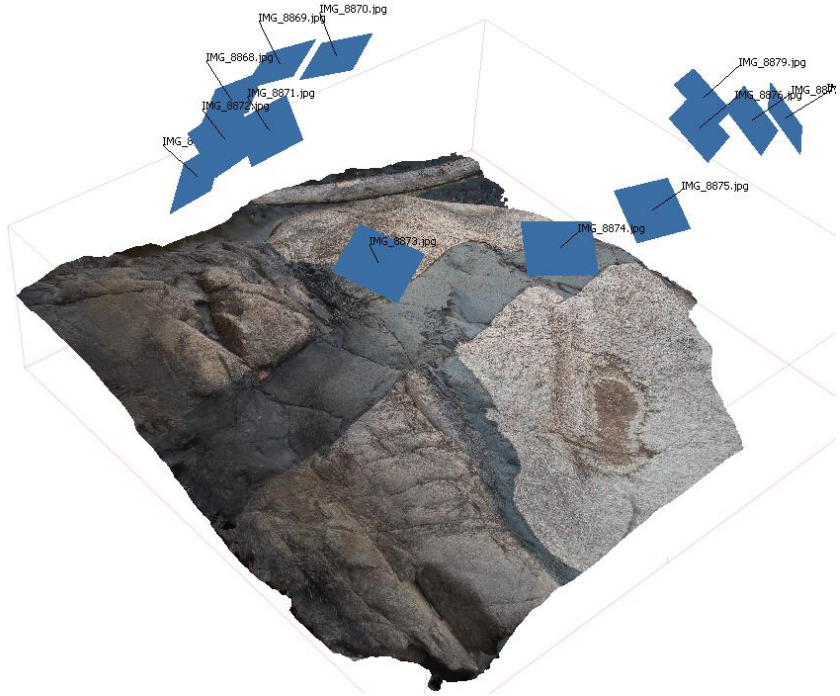
**3D reconstruction relies on imaging the same points from multiple locations – best to move the camera for each frame.**

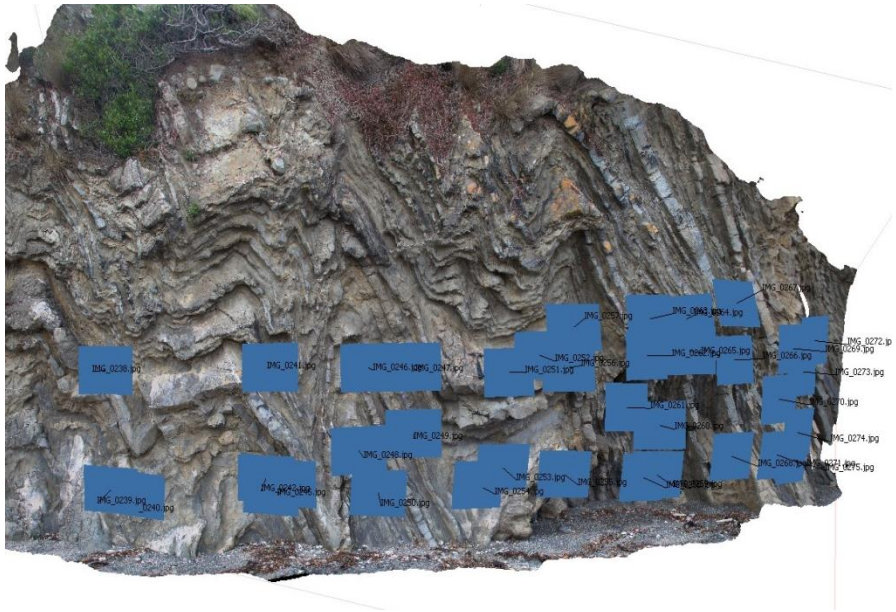
**All features that need to be imaged in 3D should appear in at least three images.**

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

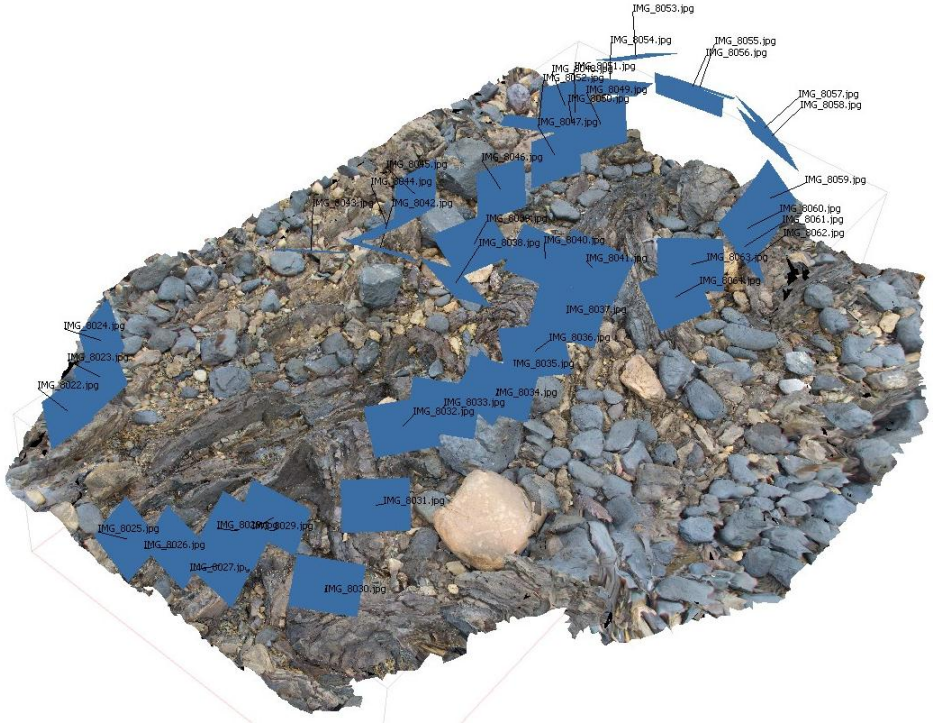
**For complex objects many images may be needed to resolve the irregular geometry.**

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



# Image Geometry

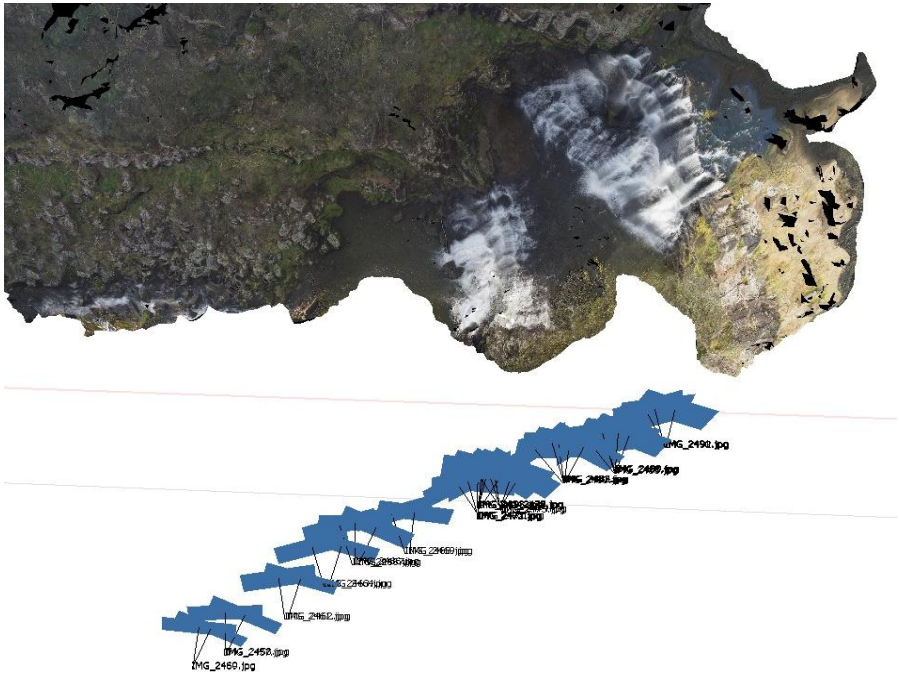


**Best to image from multiple directions and to move slightly for each image.**

**Geometric reconstruction relies on “structure from motion”**

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

**In some cases fan shooting can lead to poor geometric models or to failure of the geometric reconstruction algorithm.**

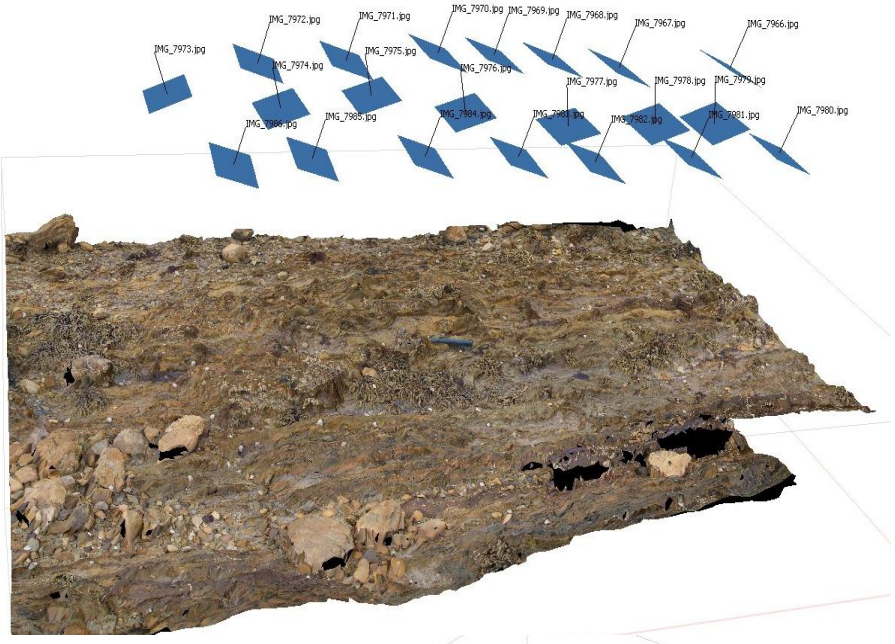


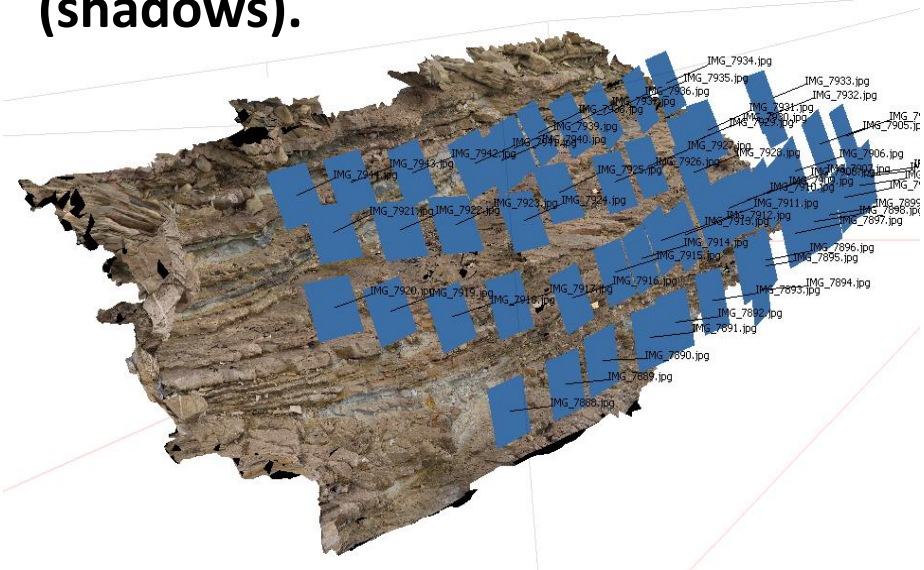
# Large Outcrops

**Visualisations of large ‘flat’ outcrops (pavements) can be achieved by systematic high angle oblique photography (10m x 10m).**

**Set the camera to wide angle and ‘shoot’ forwards and downwards.**

**Best to image in both directions but may be limited by illumination issues (shadows).**




# Image Scales

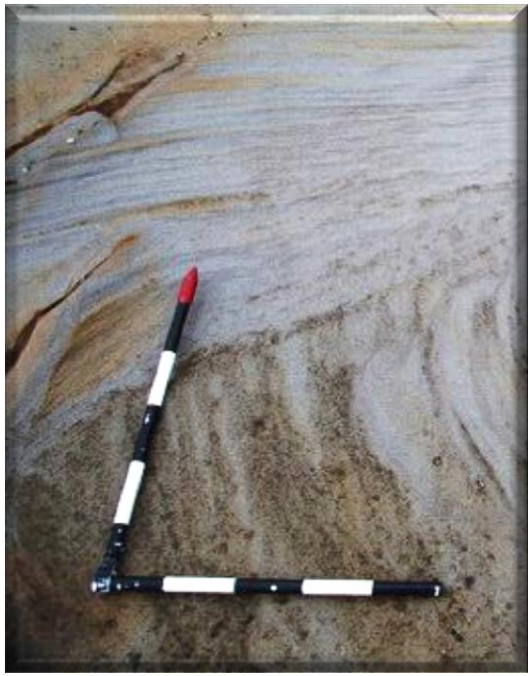
**Like conventional photography, all 3D visualisations should include scales.**

**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 3D coordinates can be provided.**

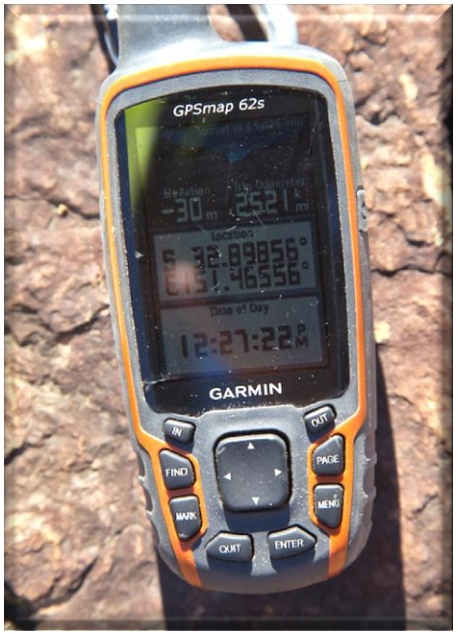
**Hinged scale bars are suitable for georectification of objects up to 5-10m.**

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



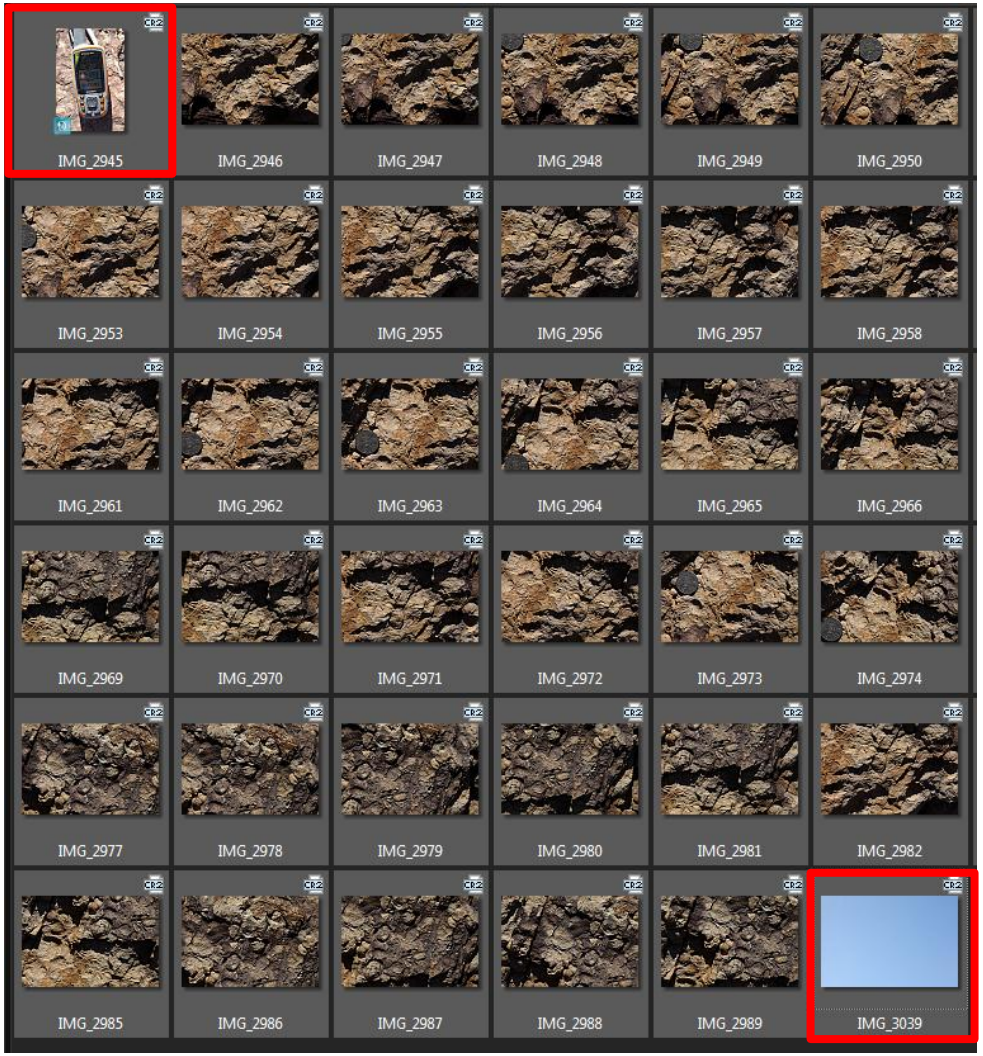
# Image Sequence

**Use extra frames to mark the beginning and end of a visualisation photo sequence to assist data processing**




***Start with a GPS photo***

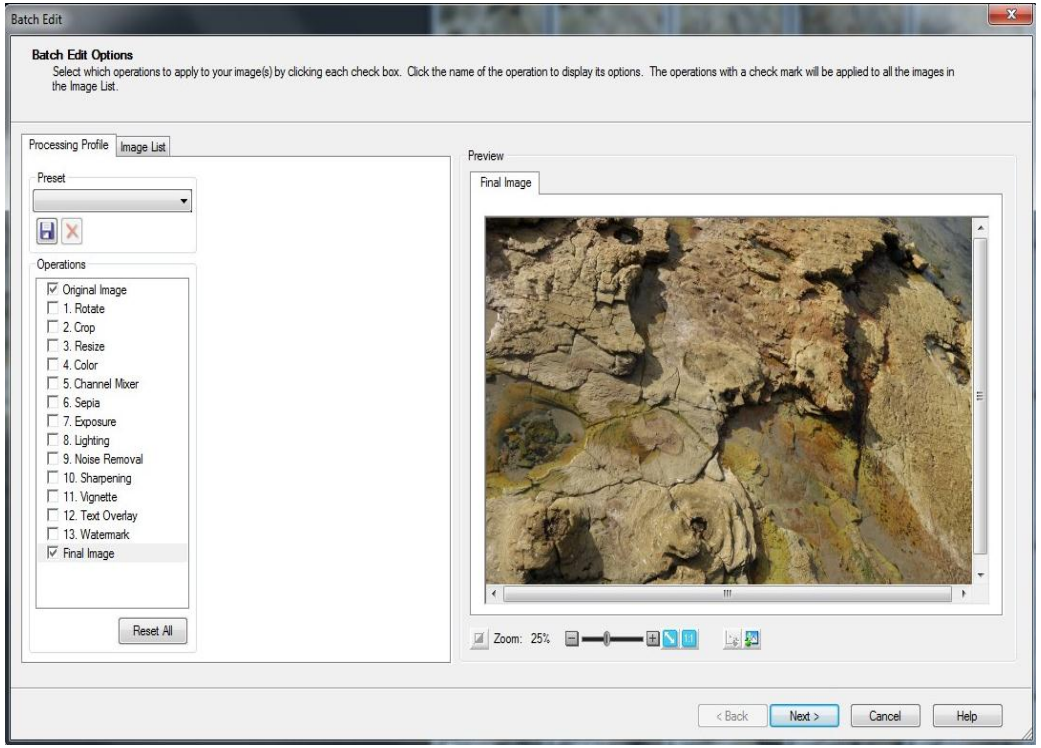
*(provides time and a cross check with coords in your notes)*




***Finish with a 'sky' photo***

# Image Processing

**In most cases, image processing steps should be applied consistently with the same parameters to all images in a visualisation sequence.**




**This is most readily achieved using applications such as Lightroom and ACDSee that allow batch processing of multiple images.**

**These software packages also allow non-permanent (reversable) changes, particularly to RAW images.**

**Changes in lighting during a photo sequence can be corrected but this usually has to be done on an image-by-image basis.**

# The issue of Scale

**When photographing geological features we often want to see both "the forest and the trees"**

**Conventional photographs, even with modern DSLR cameras, do not allow resolution of features at multiple scales**

# Deep Zoom (gigapixel) Imagery

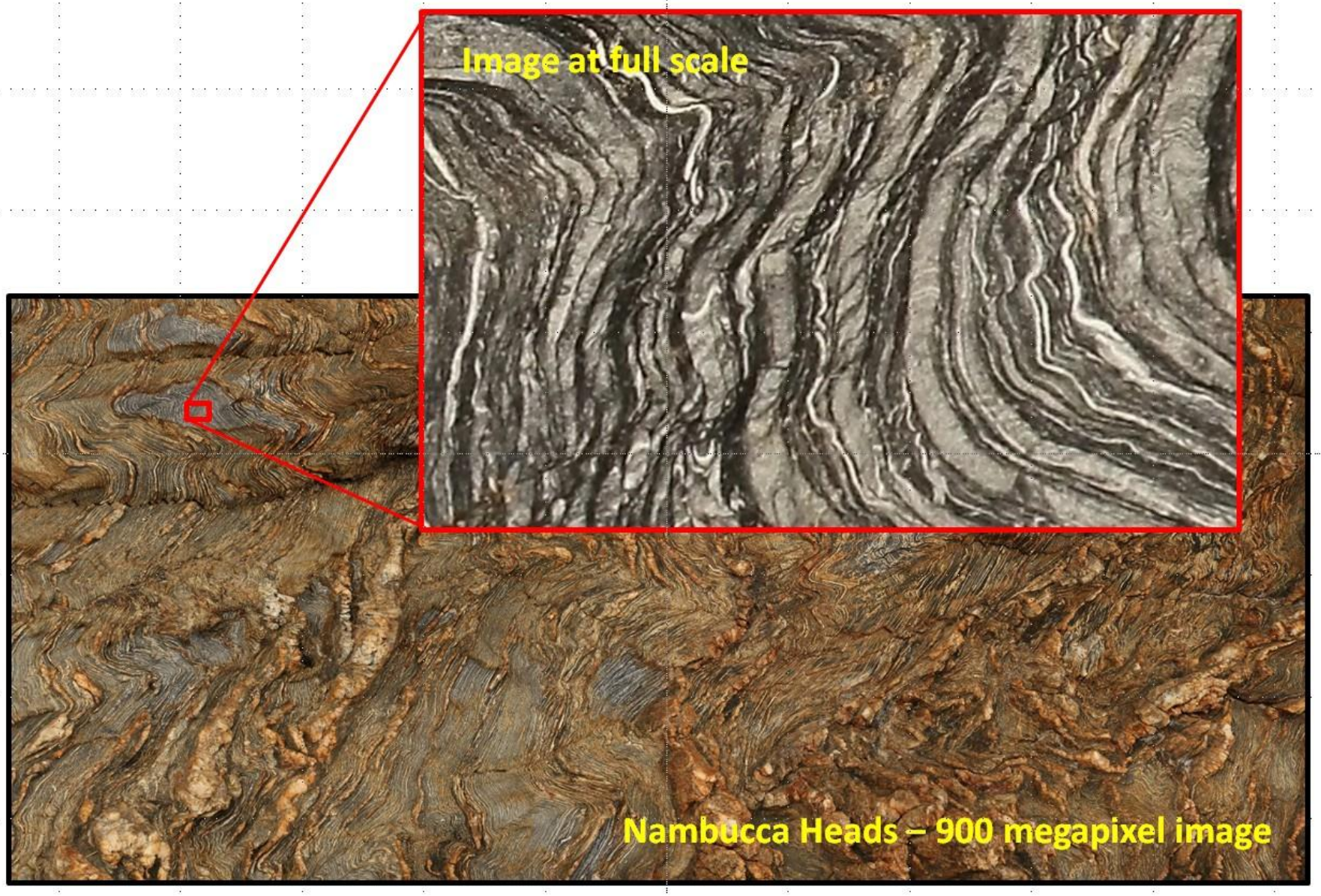

**Robotic camera heads and long focal length lenses allows capture of amazing detail over large areas.**

***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 display of multi-gigapixel images.***

# Example Gigapan Image



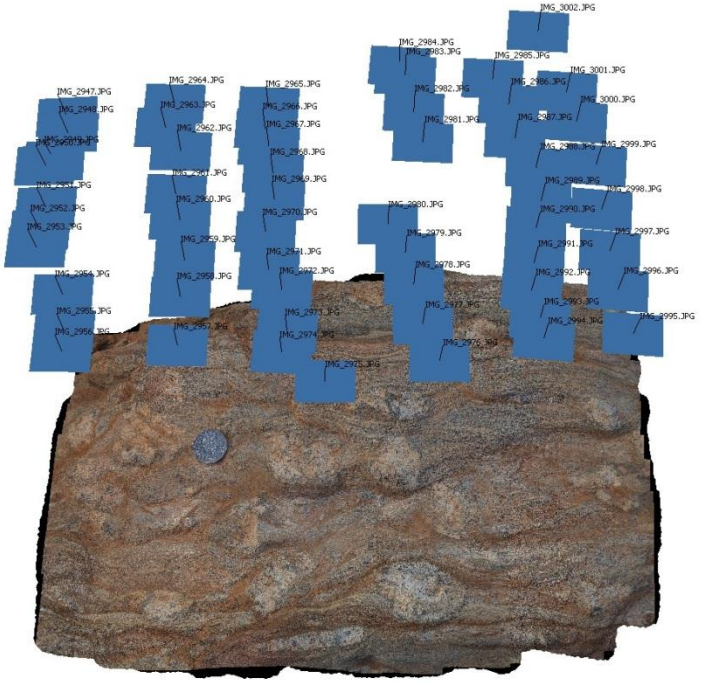
# Orthoimagery


**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.**

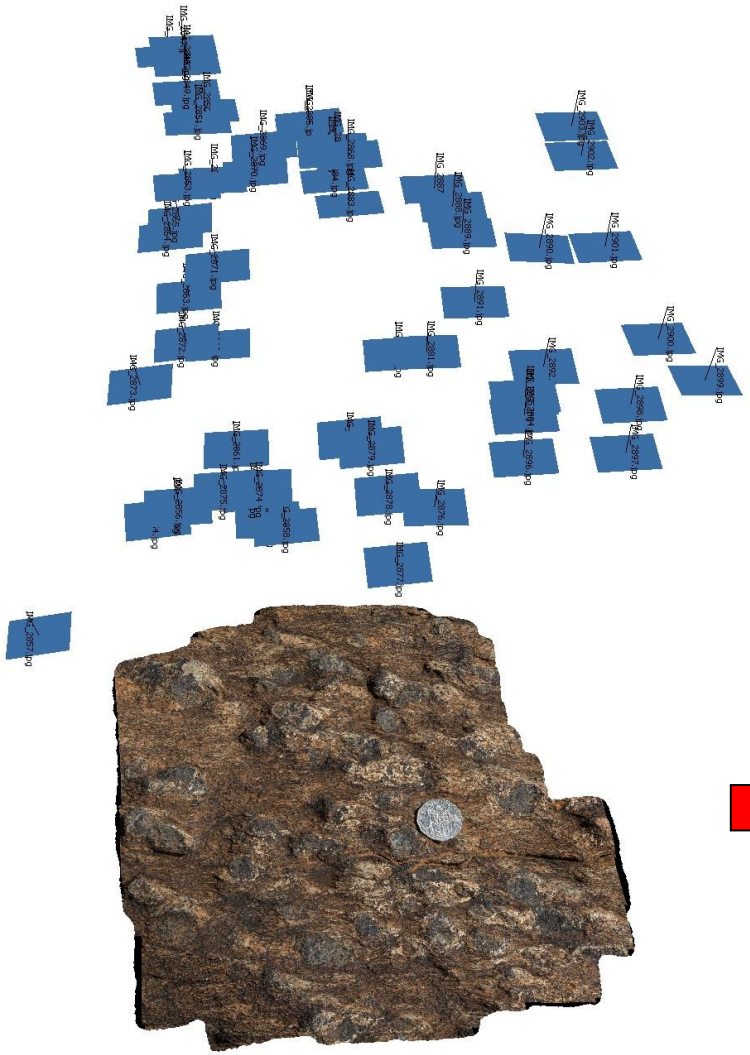
**At close range, deep zoom images are best created using digital photogrammetry**

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

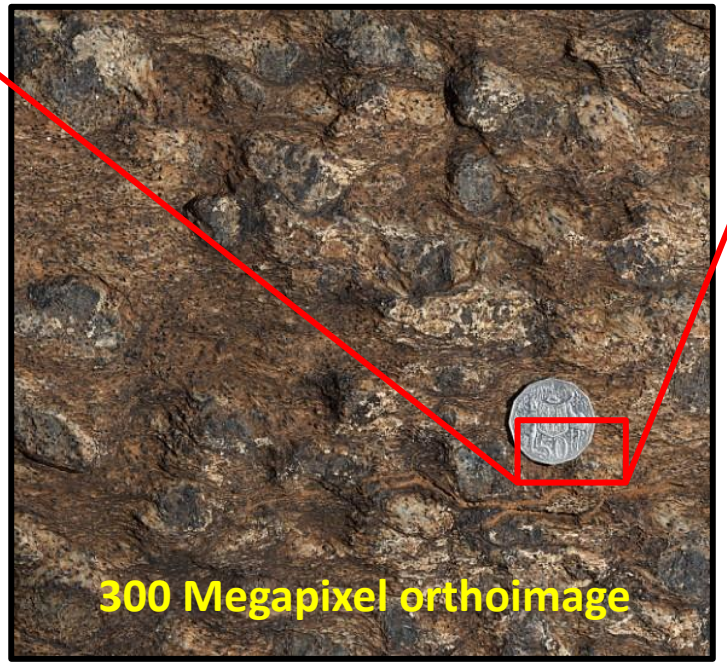
**Photogrammetry takes the model geometry into account and allows detailed orthoimages from any viewpoint**



# Orthoimagery Example



3D Photogrammetric Model

# Viewpoint Issues

**Geological features may not be well depicted from a conventional terrestrial viewpoint**

*Picanniny Point - **NE Tasmania***

**…. but may be clearly seen from above**

# UAV Photogrammetry

## Prices Bay - SE Tasmania

50m

1m

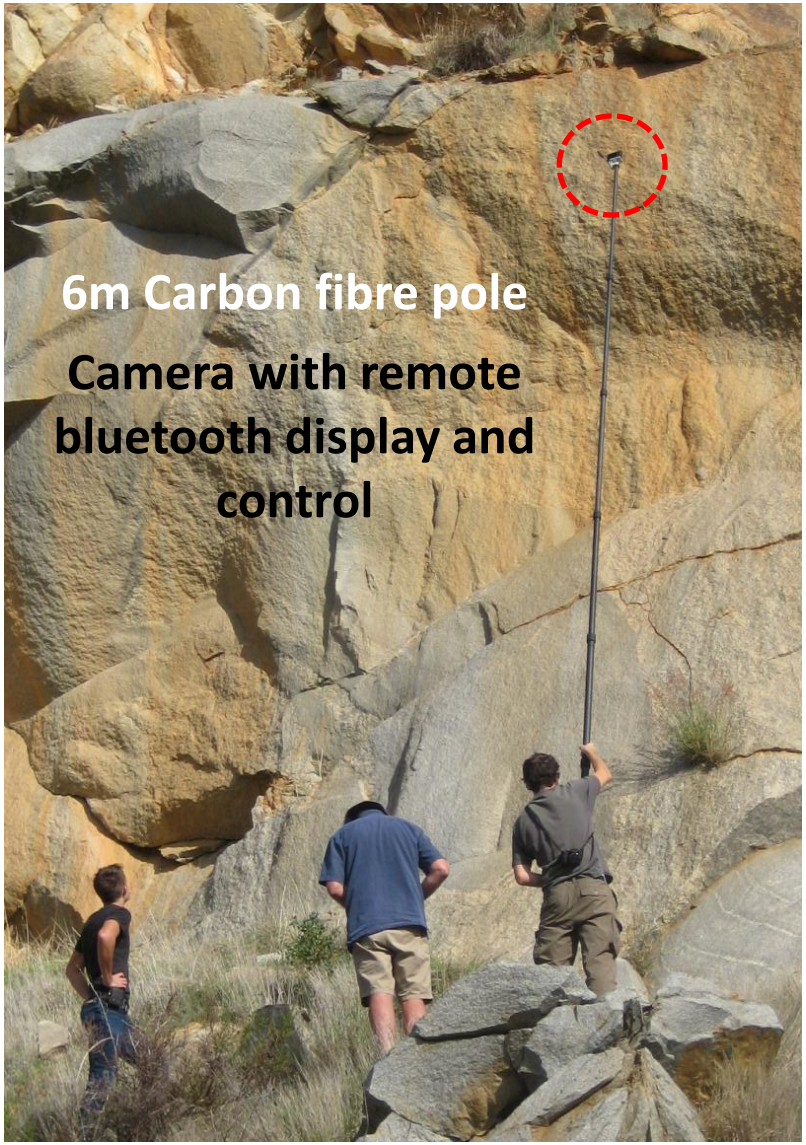
1cm pixels

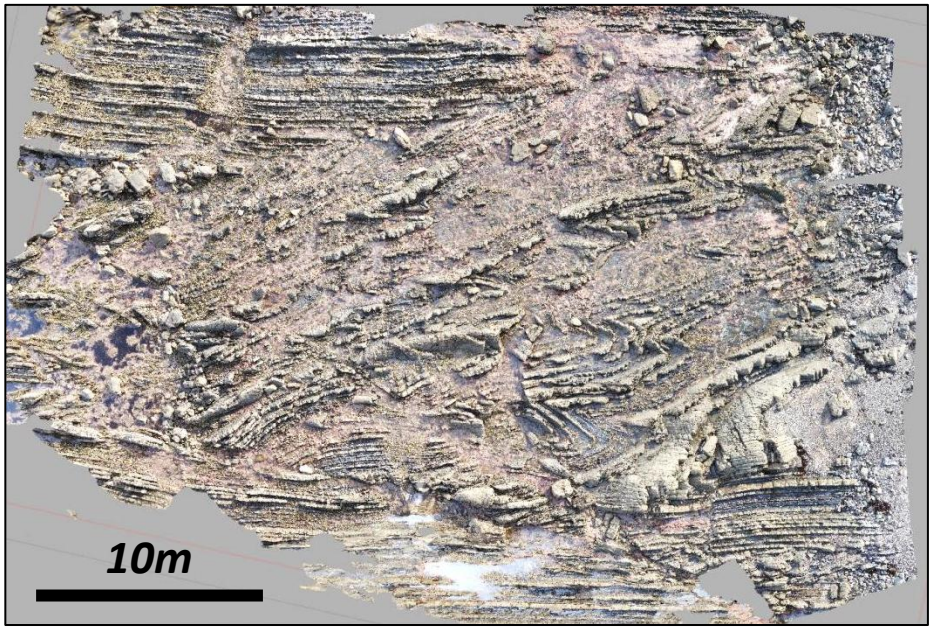
# UAV Models

***Neoproterozoic – Cambrian contact Wilkawillina Gorge S.A.***

***Peak Hill Gold Mine NSW***

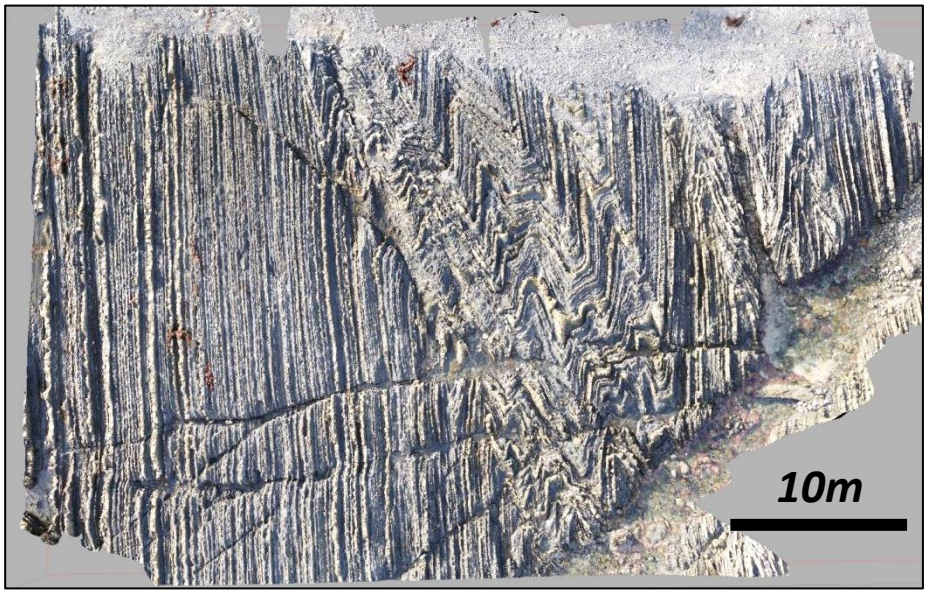
# Pole Photogrammetry




Cape Liptrap

## Pole Photography - 3D models



# Full Spherical Panoramas


**Single image with a 360 x 180 degree field of view from a single location.**

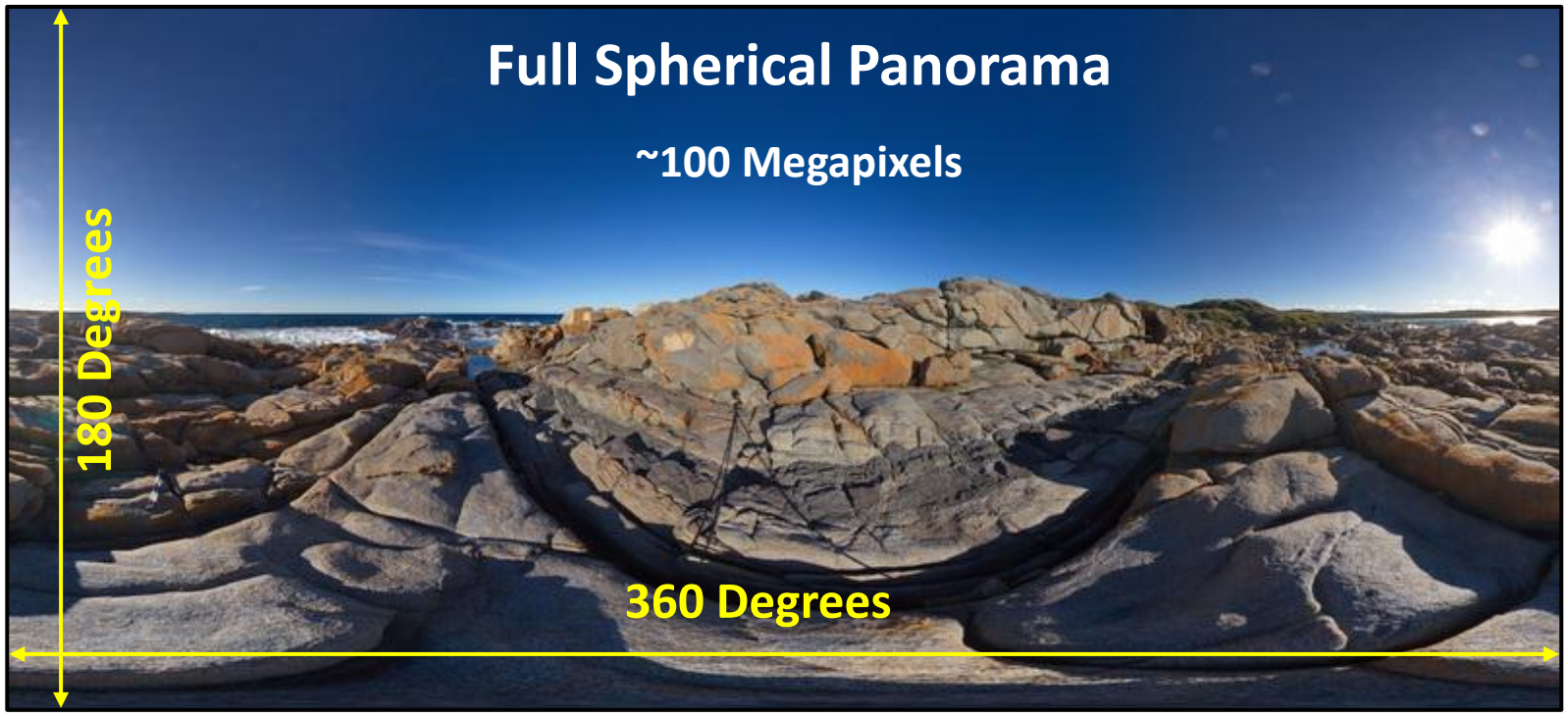
**Best acquired with a DSLR, a fisheye lens.**

**Use a panorama head if possible to rotate around the optic centre of the lens.**

**Can be acquired by handheld photography but the quality of the stitch is often poor, particularly in the near field.**

# Full Spherical Panoramas

## 7 images – 13mm lens



# AusGeol.org

## A Virtual Library of Australia's Geology

AusGeol.org
VIRTUAL LIBRARY OF AUSTRALIA'S GEOLOGY

Office for Learning & Teaching

## OLT Innovation and Development Grant 2014

**February 2015 – February 2017**

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THE UNIVERSITY OF QUEENSLAND
THE UNIVERSITY OF WESTERN AUSTRALIA
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