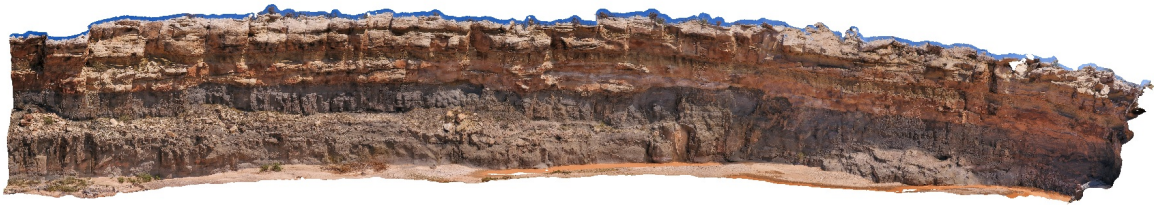


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# Survey Data

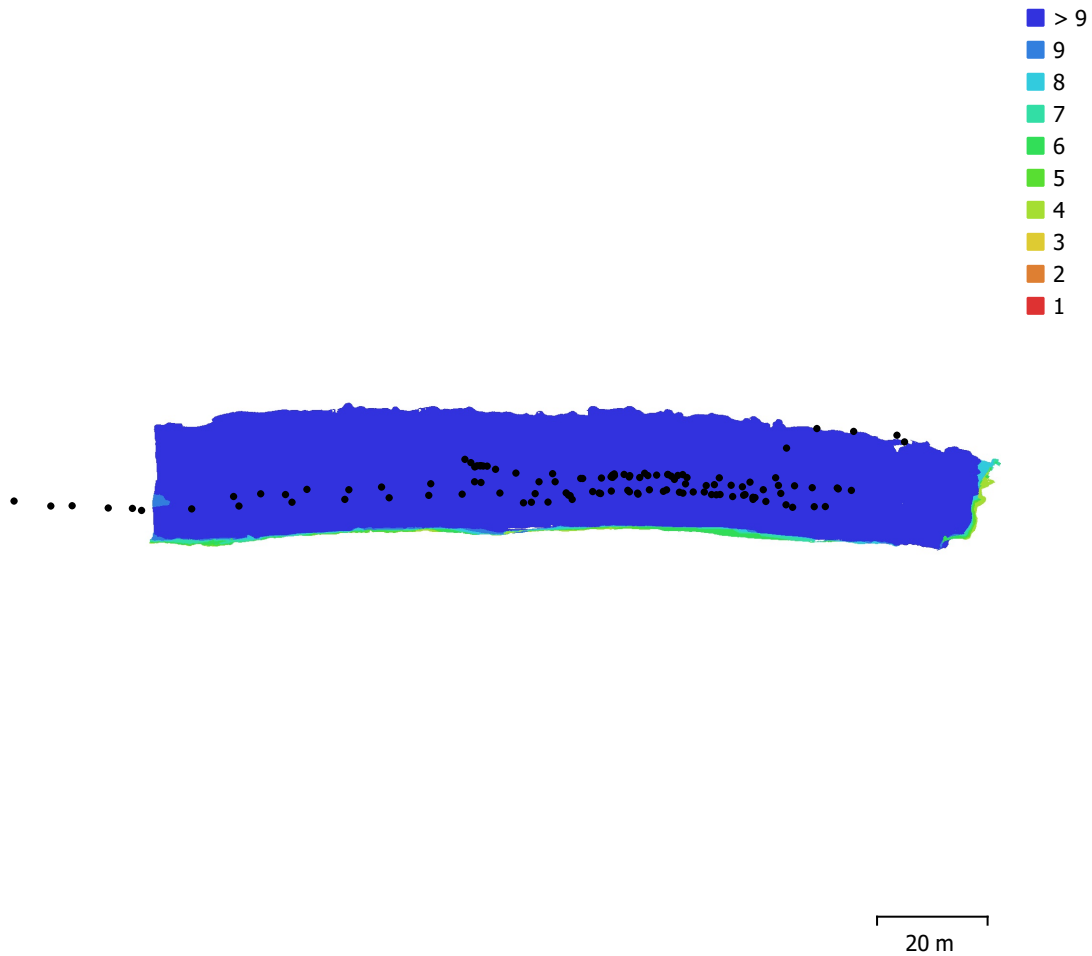


Fig. 1. Camera locations and image overlap.

Number of images:	117	Camera stations:	116
Flying altitude:	19.1 m	Tie points:	160,983
Ground resolution:	7.44 mm/pix	Projections:	416,868
Coverage area:	3.19e+03 m <sup>2</sup>	Reprojection error:	0.686 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC330 (3.61mm)	4000 x 3000	3.61 mm	1.56 x 1.56 $\mu$ m	No

Table 1. Cameras.

# Camera Calibration

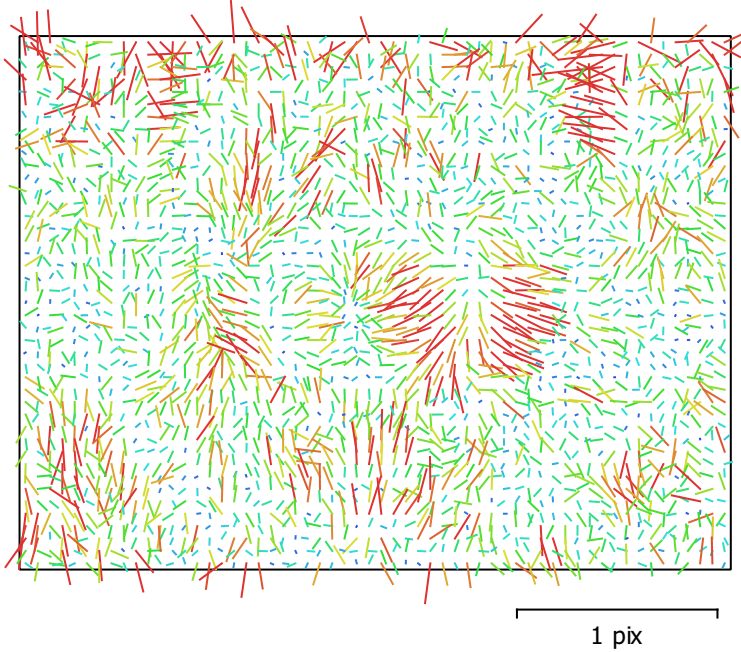


Fig. 2. Image residuals for FC330 (3.61mm).

## FC330 (3.61mm)

117 images

Type  
Frame

Resolution  
**4000 x 3000**

Focal Length  
**3.61 mm**

Pixel Size  
**1.56 x 1.56 μm**

	Value	Error	F	Cx	Cy	K1	K2	K3	P1	P2
<b>F</b>	<b>2340.59</b>	0.11	1.00	0.03	-0.11	0.14	0.07	-0.07	-0.01	-0.04
<b>Cx</b>	<b>-9.76345</b>	0.24		1.00	0.03	0.04	-0.00	0.00	0.97	0.02
<b>Cy</b>	<b>-1.95529</b>	0.13			1.00	-0.03	0.01	-0.01	0.04	0.86
<b>K1</b>	<b>-0.00328048</b>	5.9e-05				1.00	-0.91	0.84	0.03	-0.04
<b>K2</b>	<b>-0.00262381</b>	0.00012					1.00	-0.98	-0.00	0.00
<b>K3</b>	<b>0.000935099</b>	8e-05						1.00	0.00	-0.01
<b>P1</b>	<b>-1.14829e-06</b>	2.3e-05							1.00	0.02
<b>P2</b>	<b>3.43414e-05</b>	1.1e-05								1.00

Table 2. Calibration coefficients and correlation matrix.

# Camera Locations

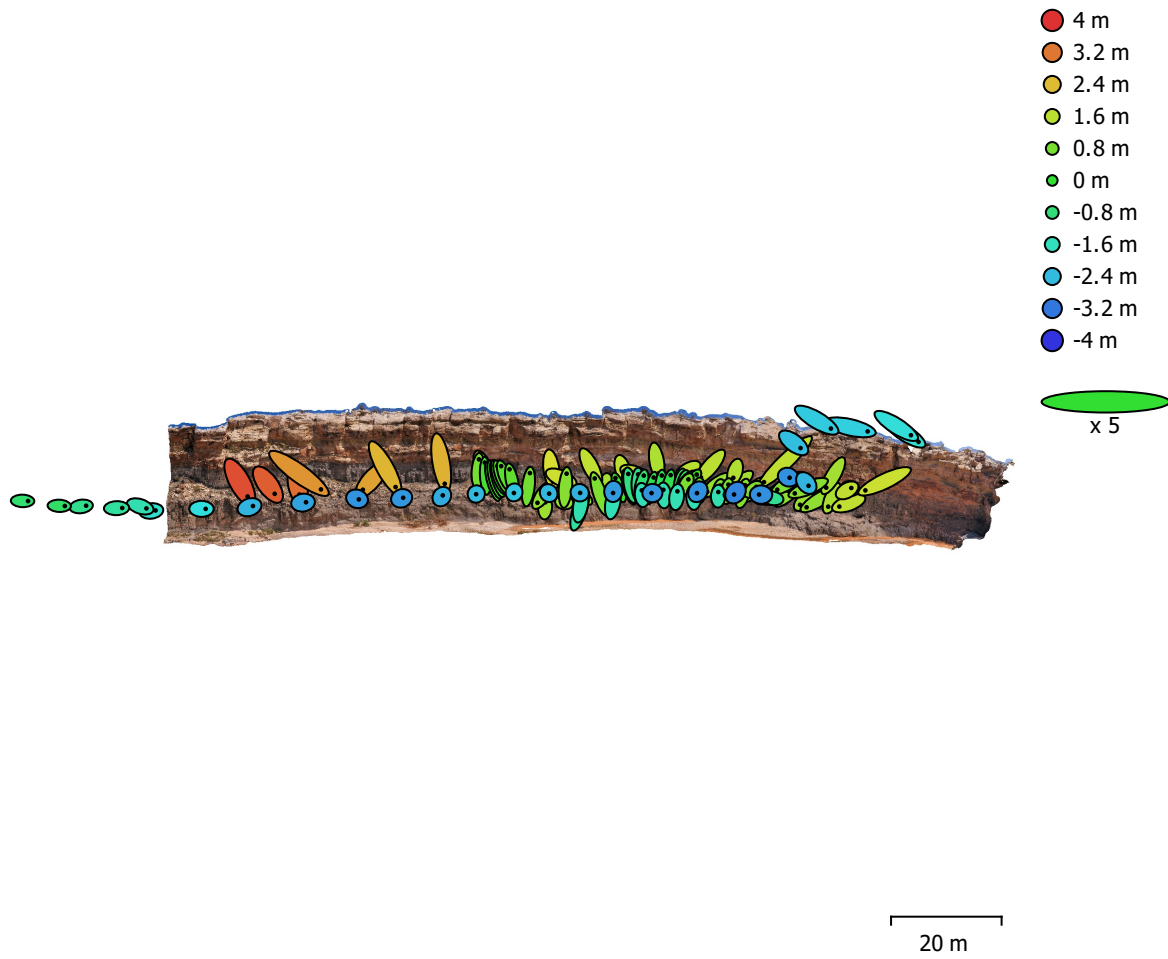


Fig. 3. Camera locations and error estimates.

Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.

Estimated camera locations are marked with a black dot.

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
0.462673	0.607172	1.68534	0.763363	1.85016

Table 3. Average camera location error.

X - Longitude, Y - Latitude, Z - Altitude.

# Digital Elevation Model

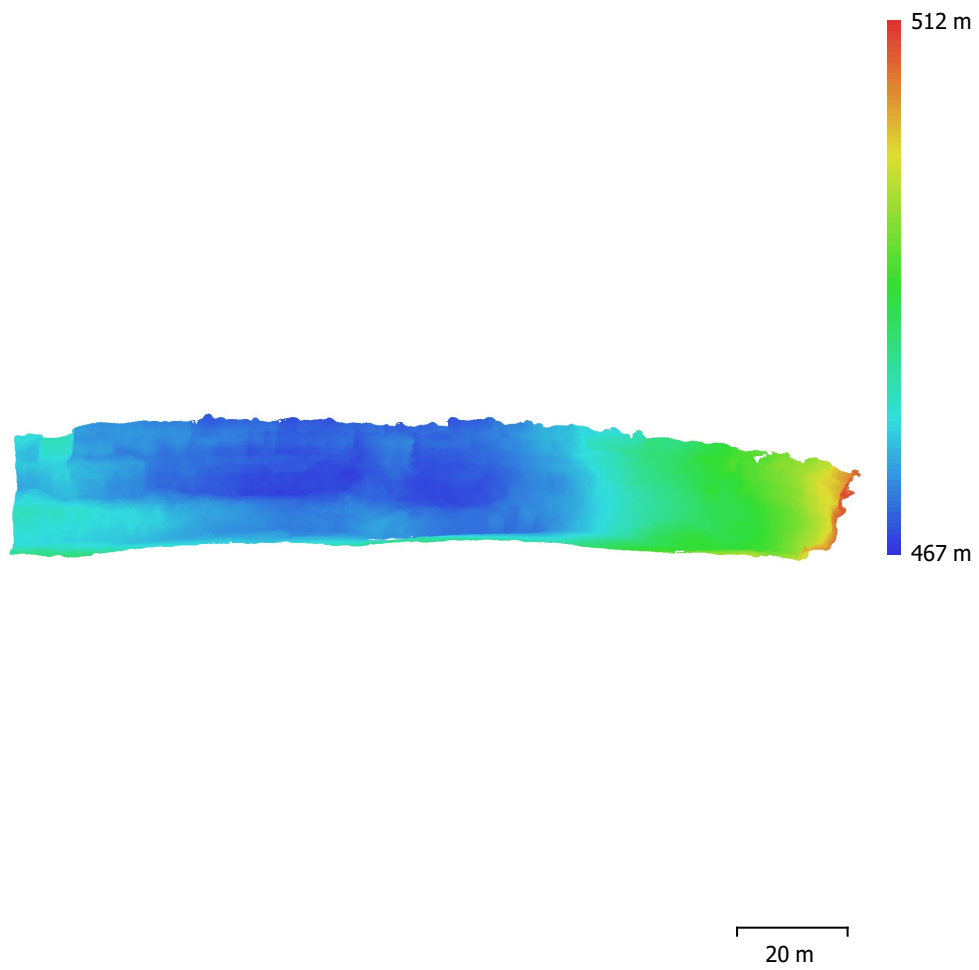


Fig. 4. Reconstructed digital elevation model.

Resolution: 1.49 cm/pix  
Point density: 0.452 points/cm<sup>2</sup>

# Processing Parameters

## General

Cameras	117
Aligned cameras	116
Coordinate system	WGS 84 (EPSG::4326)
Rotation angles	Yaw, Pitch, Roll

## Point Cloud

Points	160,983 of 214,982
RMS reprojection error	0.158049 (0.686089 pix)
Max reprojection error	0.399992 (15.1378 pix)
Mean key point size	3.97519 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	3.05861

## Alignment parameters

Accuracy	High
Generic preselection	Yes
Reference preselection	Source
Key point limit	20,000
Key point limit per Mpx	1,000
Tie point limit	0
Exclude stationary tie points	Yes
Guided image matching	No
Adaptive camera model fitting	No
Matching time	31 seconds
Matching memory usage	606.78 MB
Alignment time	1 minutes 0 seconds
Alignment memory usage	110.70 MB
Date created	2022:10:04 14:13:09
Software version	1.7.3.12426
File size	14.35 MB

## Depth Maps

Count	115
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	2 minutes 10 seconds
Memory usage	2.25 GB
Date created	2022:10:04 14:29:15
Software version	1.7.3.12426
File size	382.73 MB

## Dense Point Cloud

Points	27,248,373
Point colors	3 bands, uint8
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	2 minutes 10 seconds
Memory usage	2.25 GB
<b>Dense cloud generation parameters</b>	
Processing time	8 minutes 21 seconds

Memory usage	4.91 GB
Date created	2022:10:04 14:37:37
Software version	1.7.3.12426
File size	356.85 MB
<b>Model</b>	
Faces	4,544,674
Vertices	2,279,153
Vertex colors	3 bands, uint8
Texture	4,096 x 4,096, 4 bands, uint8
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	2 minutes 10 seconds
Memory usage	2.25 GB
<b>Reconstruction parameters</b>	
Surface type	Arbitrary
Source data	Dense cloud
Interpolation	Enabled
Strict volumetric masks	No
Processing time	14 minutes 2 seconds
Memory usage	14.63 GB
<b>Texturing parameters</b>	
Mapping mode	Generic
Blending mode	Mosaic
Texture size	4,096
Enable hole filling	Yes
Enable ghosting filter	Yes
UV mapping time	5 minutes 21 seconds
UV mapping memory usage	4.94 GB
Blending time	32 seconds
Blending memory usage	1.93 GB
Blending GPU memory usage	1.06 GB
Date created	2022:10:04 14:39:34
Software version	1.7.3.12426
File size	226.46 MB
<b>DEM</b>	
Size	7,014 x 10,929
Coordinate system	WGS 84 (EPSG::4326)
<b>Reconstruction parameters</b>	
Source data	Dense cloud
Interpolation	Enabled
Processing time	18 seconds
Memory usage	307.00 MB
Date created	2023:02:21 10:09:48
Software version	1.7.3.12426
File size	101.00 MB
<b>System</b>	
Software name	Agisoft Metashape Professional
Software version	1.7.3 build 12426
OS	Windows 64 bit
RAM	63.68 GB
CPU	Intel(R) Xeon(R) W-2145 CPU @ 3.70GHz
GPU(s)	NVIDIA GeForce RTX 2080 Ti

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# Survey Data

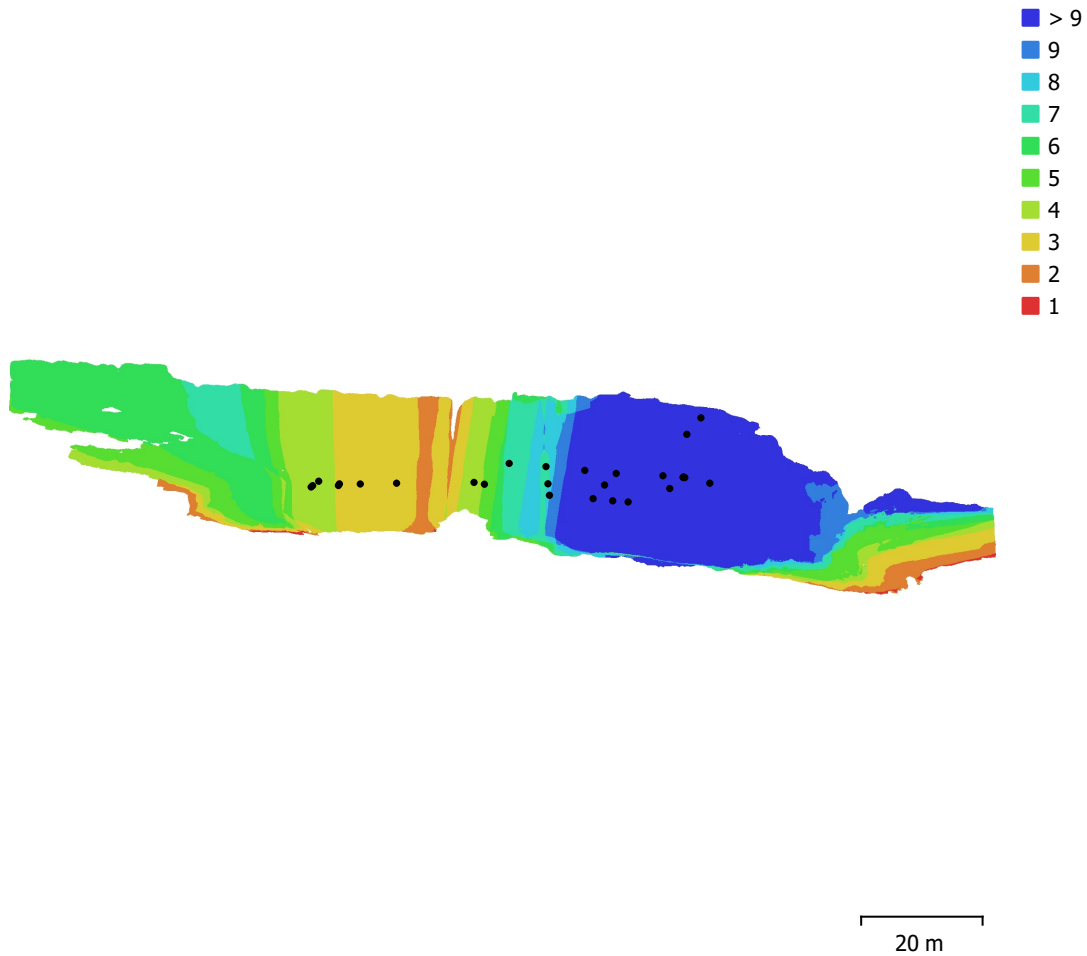


Fig. 1. Camera locations and image overlap.

Number of images:	27	Camera stations:	27
Flying altitude:	30.1 m	Tie points:	29,105
Ground resolution:	1.12 cm/pix	Projections:	70,974
Coverage area:	3.26e+03 m <sup>2</sup>	Reprojection error:	0.735 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC330 (3.61mm)	4000 x 3000	3.61 mm	1.56 x 1.56 $\mu$ m	No

Table 1. Cameras.

# Camera Calibration

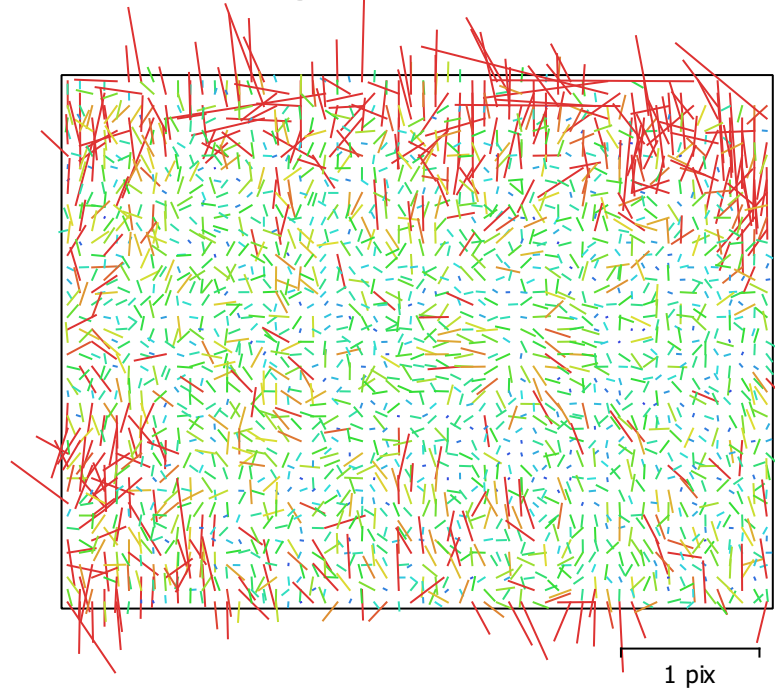


Fig. 2. Image residuals for FC330 (3.61mm).

## FC330 (3.61mm)

27 images

Type **Frame** Resolution **4000 x 3000** Focal Length **3.61 mm** Pixel Size **1.56 x 1.56  $\mu$ m**

	Value	Error	F	Cx	Cy	K1	K2	K3	P1	P2
<b>F</b>	<b>2343.79</b>	0.37	1.00	-0.12	-0.14	0.25	0.09	-0.11	-0.10	-0.15
<b>Cx</b>	<b>-1.9612</b>	0.69		1.00	0.01	-0.01	0.02	-0.03	0.98	0.05
<b>Cy</b>	<b>-10.976</b>	0.52			1.00	-0.07	0.04	-0.05	0.02	0.89
<b>K1</b>	<b>-0.00258944</b>	0.00018				1.00	-0.88	0.80	-0.00	-0.11
<b>K2</b>	<b>-0.00290576</b>	0.00037					1.00	-0.98	0.02	0.05
<b>K3</b>	<b>0.000409635</b>	0.00025						1.00	-0.03	-0.05
<b>P1</b>	<b>0.000467859</b>	7.5e-05							1.00	0.06
<b>P2</b>	<b>-0.000230677</b>	4.3e-05								1.00

Table 2. Calibration coefficients and correlation matrix.

# Camera Locations

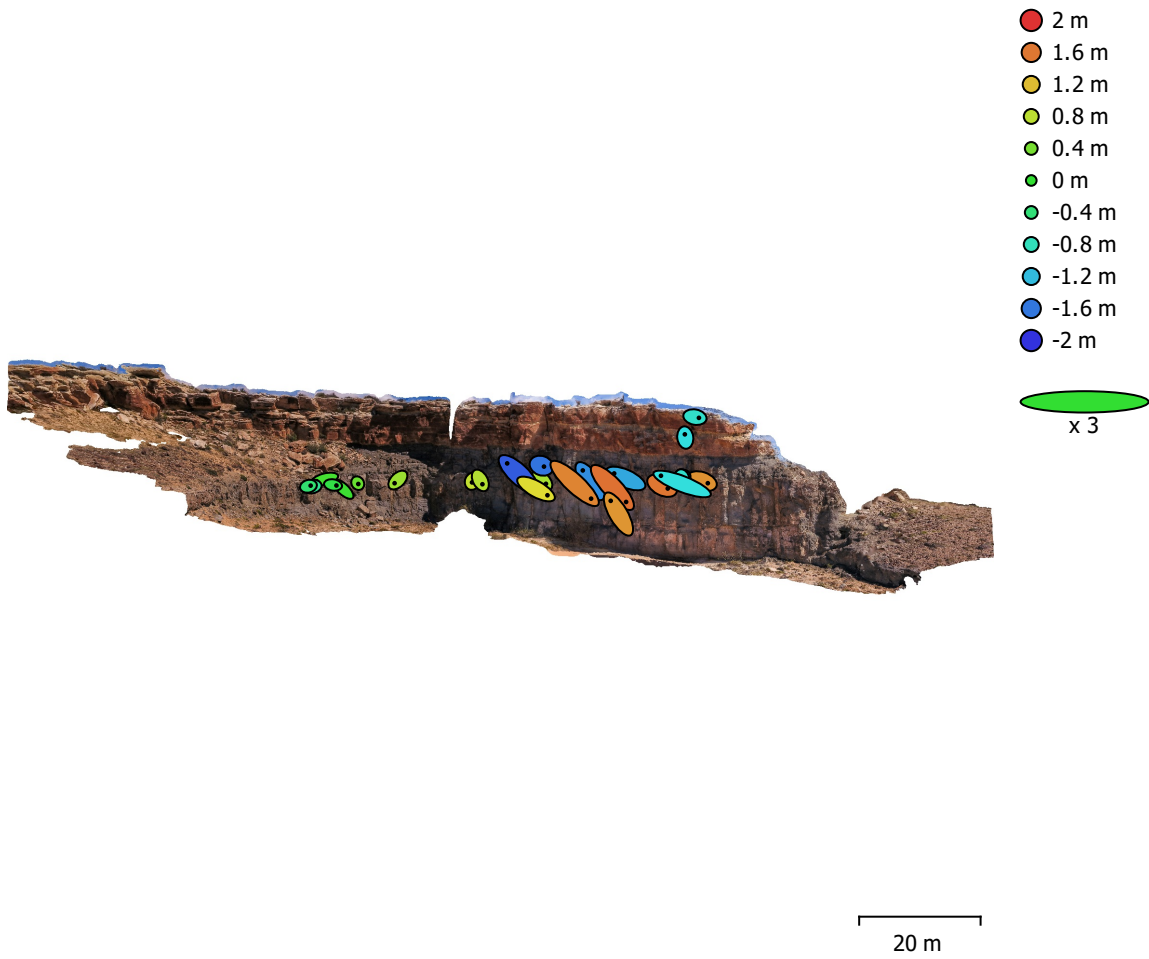


Fig. 3. Camera locations and error estimates.

Z error is represented by ellipse color. X,Y errors are represented by ellipse shape. Estimated camera locations are marked with a black dot.

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
0.871382	0.702939	1.08183	1.11957	1.55685

Table 3. Average camera location error.  
X - Longitude, Y - Latitude, Z - Altitude.

# Digital Elevation Model

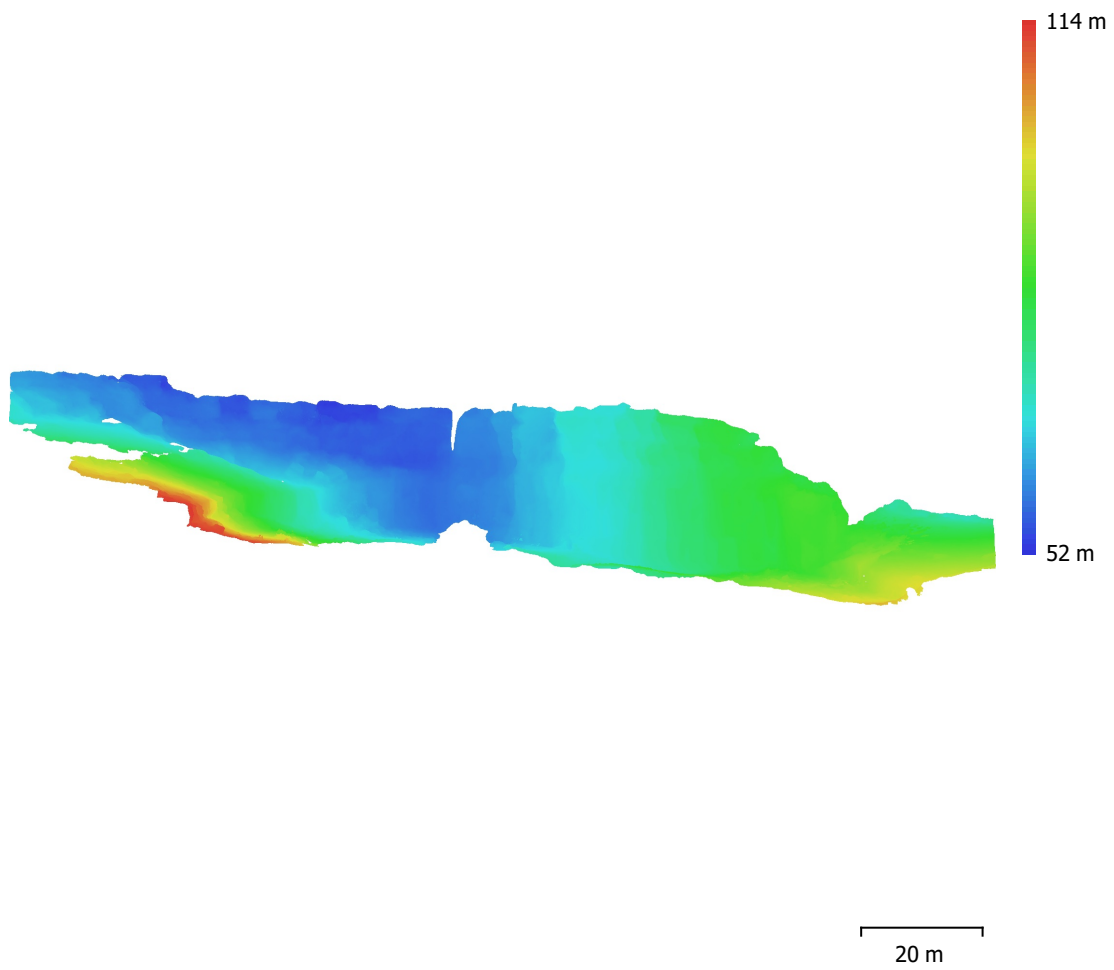


Fig. 4. Reconstructed digital elevation model.

Resolution: 2.25 cm/pix  
Point density: 0.198 points/cm<sup>2</sup>

# Processing Parameters

## General

Cameras	27
Aligned cameras	27
Coordinate system	WGS 84 (EPSG::4326)
Rotation angles	Yaw, Pitch, Roll

## Point Cloud

Points	29,105 of 46,028
RMS reprojection error	0.15244 (0.73536 pix)
Max reprojection error	0.399993 (9.22311 pix)
Mean key point size	4.22771 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	2.90501

## Alignment parameters

Accuracy	High
Generic preselection	Yes
Reference preselection	Source
Key point limit	20,000
Key point limit per Mpx	1,000
Tie point limit	0
Exclude stationary tie points	Yes
Guided image matching	No
Adaptive camera model fitting	No
Matching time	7 seconds
Matching memory usage	268.57 MB
Alignment time	15 seconds
Alignment memory usage	34.27 MB
Date created	2022:09:22 11:06:50
Software version	1.7.3.12426
File size	2.84 MB

## Depth Maps

Count	27
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	28 seconds
Memory usage	1.32 GB
Date created	2022:09:22 11:11:05
Software version	1.7.3.12426
File size	61.84 MB

## Dense Point Cloud

Points	12,835,160
Point colors	3 bands, uint8

## Depth maps generation parameters

Quality	High
Filtering mode	Mild
Processing time	28 seconds
Memory usage	1.32 GB

## Dense cloud generation parameters

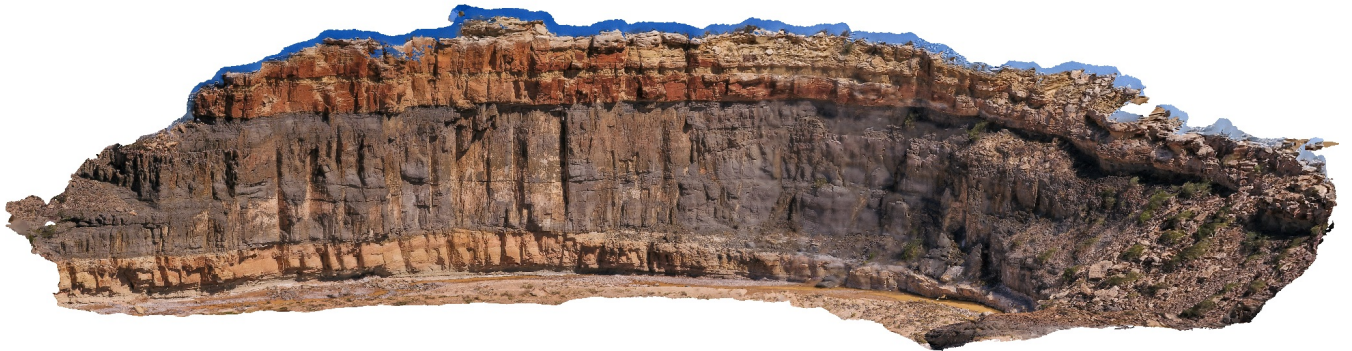
Processing time	43 seconds
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Memory usage	2.60 GB
Date created	2022:09:22 11:11:48
Software version	1.7.3.12426
File size	168.10 MB
<b>Model</b>	
Faces	2,259,764
Vertices	1,136,351
Vertex colors	3 bands, uint8
Texture	4,096 x 4,096, 4 bands, uint8
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	28 seconds
Memory usage	1.32 GB
<b>Reconstruction parameters</b>	
Surface type	Arbitrary
Source data	Dense cloud
Interpolation	Enabled
Strict volumetric masks	No
Processing time	6 minutes 45 seconds
Memory usage	7.13 GB
<b>Texturing parameters</b>	
Mapping mode	Generic
Blending mode	Mosaic
Texture size	4,096
Enable hole filling	Yes
Enable ghosting filter	Yes
UV mapping time	7 minutes 9 seconds
UV mapping memory usage	4.04 GB
Blending time	11 seconds
Blending memory usage	1.63 GB
Blending GPU memory usage	955.86 MB
Date created	2022:09:22 11:14:14
Software version	1.7.3.12426
File size	128.93 MB
<b>System</b>	
Software name	Agisoft Metashape Professional
Software version	1.7.3 build 12426
OS	Windows 64 bit
RAM	63.68 GB
CPU	Intel(R) Xeon(R) W-2145 CPU @ 3.70GHz
GPU(s)	NVIDIA GeForce RTX 2080 Ti

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# Survey Data

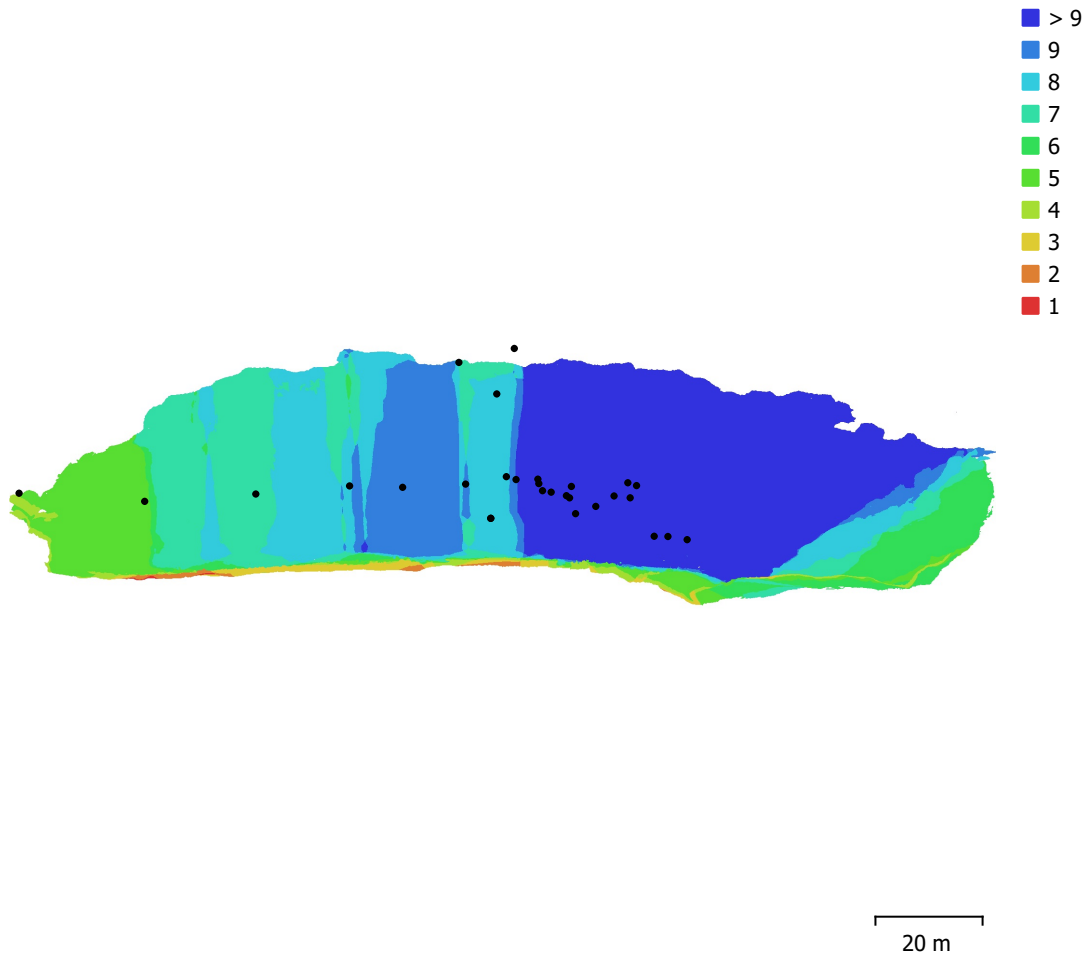


Fig. 1. Camera locations and image overlap.

Number of images:	39	Camera stations:	29
Flying altitude:	52.8 m	Tie points:	30,493
Ground resolution:	1.88 cm/pix	Projections:	73,184
Coverage area:	6.13e+03 m <sup>2</sup>	Reprojection error:	0.63 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC330 (3.61mm)	4000 x 3000	3.61 mm	1.56 x 1.56 μm	No

Table 1. Cameras.



# Camera Calibration

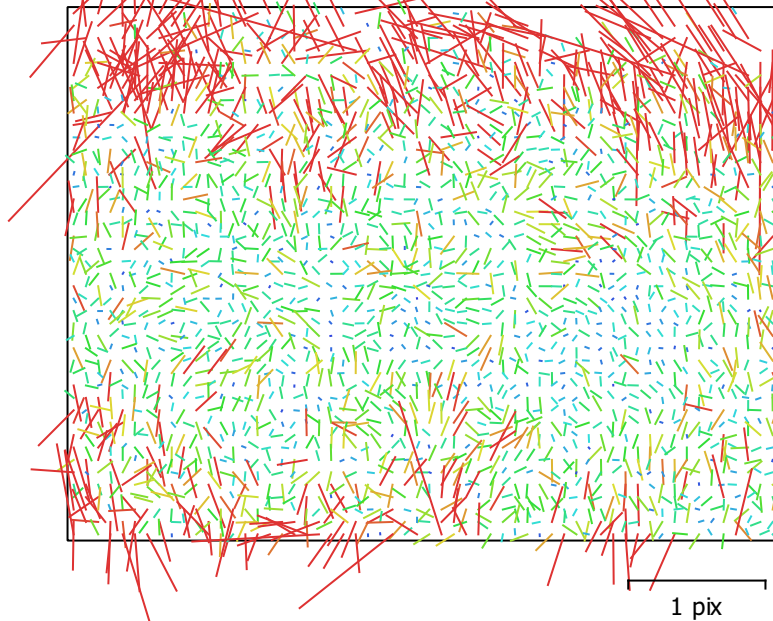


Fig. 2. Image residuals for FC330 (3.61mm).

## FC330 (3.61mm)

39 images

Type **Frame** Resolution **4000 x 3000** Focal Length **3.61 mm** Pixel Size **1.56 x 1.56  $\mu\text{m}$**

	Value	Error	F	Cx	Cy	K1	K2	K3	P1	P2
<b>F</b>	<b>2332.18</b>	0.26	1.00	-0.09	-0.18	0.27	0.09	-0.09	-0.06	-0.12
<b>Cx</b>	<b>-12.8536</b>	0.5		1.00	-0.03	-0.12	0.03	-0.02	0.98	0.00
<b>Cy</b>	<b>-17.5428</b>	0.46			1.00	-0.03	-0.01	-0.02	-0.05	0.96
<b>K1</b>	<b>-0.00135826</b>	0.00014				1.00	-0.88	0.82	-0.11	-0.05
<b>K2</b>	<b>-0.00611328</b>	0.00029					1.00	-0.98	0.02	0.01
<b>K3</b>	<b>0.00348099</b>	0.0002						1.00	-0.02	-0.04
<b>P1</b>	<b>-0.000179306</b>	5.2e-05							1.00	-0.02
<b>P2</b>	<b>-0.00156501</b>	4.2e-05								1.00

Table 2. Calibration coefficients and correlation matrix.

# Camera Locations

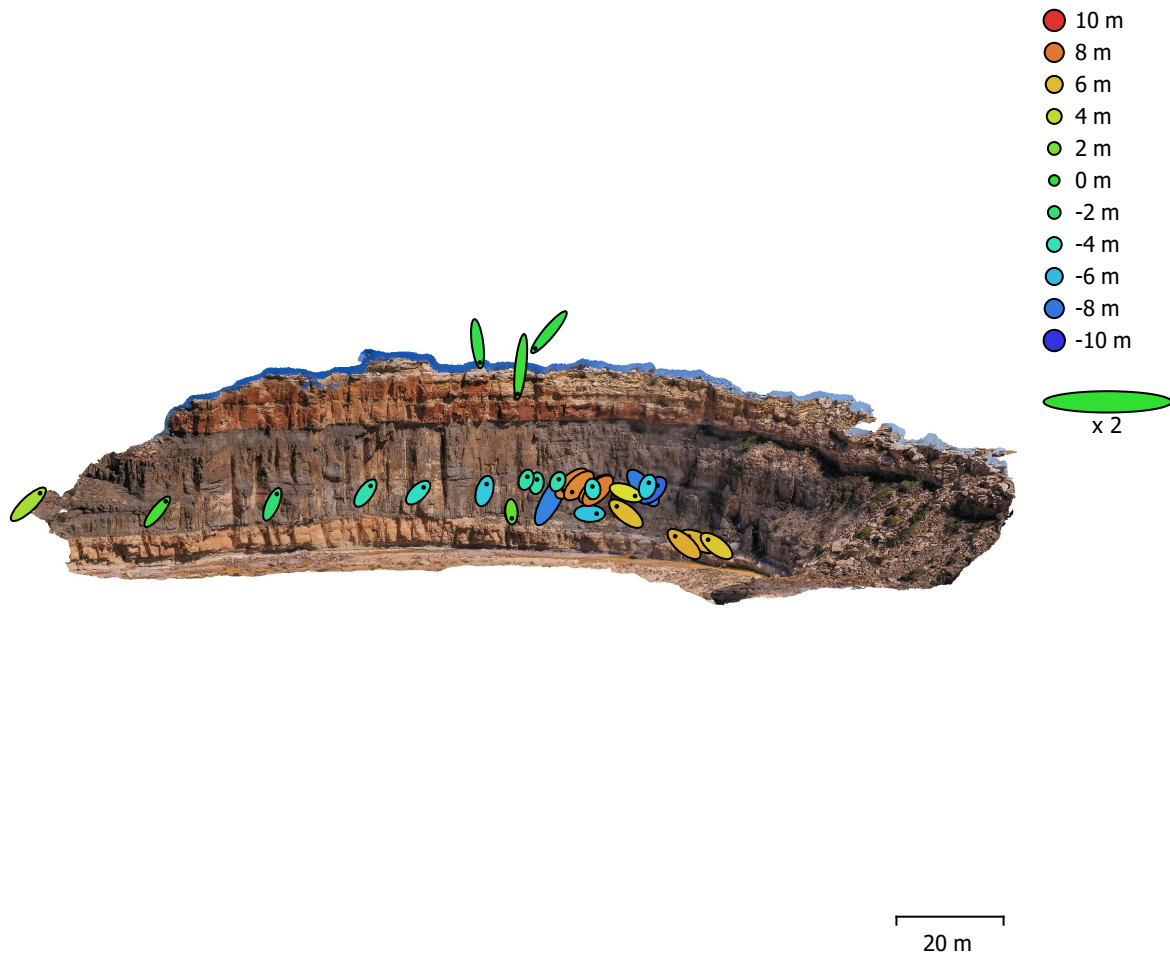


Fig. 3. Camera locations and error estimates.

Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.

Estimated camera locations are marked with a black dot.

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
1.28005	1.80416	5.24705	2.21213	5.6943

Table 3. Average camera location error.

X - Longitude, Y - Latitude, Z - Altitude.

# Digital Elevation Model

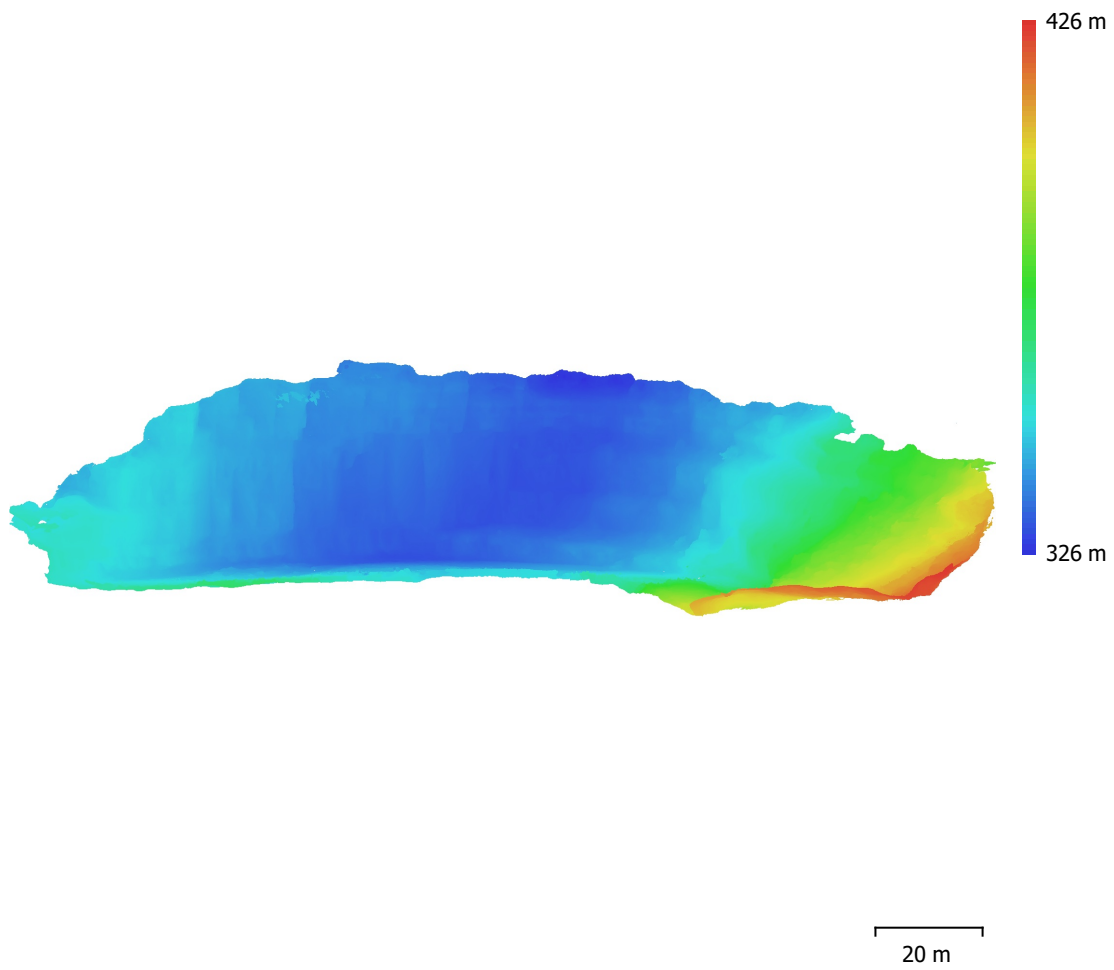


Fig. 4. Reconstructed digital elevation model.

Resolution: 3.77 cm/pix  
Point density: 705 points/m<sup>2</sup>

# Processing Parameters

## General

Cameras	39
Aligned cameras	29
Coordinate system	WGS 84 (EPSG::4326)
Rotation angles	Yaw, Pitch, Roll

## Point Cloud

Points	30,493 of 50,730
RMS reprojection error	0.146904 (0.629839 pix)
Max reprojection error	0.399967 (11.4016 pix)
Mean key point size	3.89879 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	2.47437

## Alignment parameters

Accuracy	High
Generic preselection	Yes
Reference preselection	Source
Key point limit	20,000
Key point limit per Mpx	1,000
Tie point limit	0
Exclude stationary tie points	Yes
Guided image matching	No
Adaptive camera model fitting	No
Matching time	9 seconds
Matching memory usage	317.71 MB
Alignment time	13 seconds
Alignment memory usage	42.37 MB
Date created	2022:09:22 12:48:19
Software version	1.7.3.12426
File size	2.76 MB

## Depth Maps

Count	29
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	26 seconds
Memory usage	1.48 GB
Date created	2022:09:27 12:30:09
Software version	1.7.3.12426
File size	59.25 MB

## Dense Point Cloud

Points	10,444,818
Point colors	3 bands, uint8

## Depth maps generation parameters

Quality	High
Filtering mode	Mild
Processing time	26 seconds
Memory usage	1.48 GB

## Dense cloud generation parameters

Processing time	36 seconds
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Memory usage	2.70 GB
Date created	2022:09:27 12:30:45
Software version	1.7.3.12426
File size	136.52 MB
<b>Model</b>	
Faces	1,985,838
Vertices	996,883
Vertex colors	3 bands, uint8
Texture	4,096 x 4,096, 4 bands, uint8
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	26 seconds
Memory usage	1.48 GB
<b>Reconstruction parameters</b>	
Surface type	Arbitrary
Source data	Dense cloud
Interpolation	Enabled
Strict volumetric masks	No
Processing time	5 minutes 20 seconds
Memory usage	5.55 GB
<b>Texturing parameters</b>	
Mapping mode	Generic
Blending mode	Mosaic
Texture size	4,096
Enable hole filling	Yes
Enable ghosting filter	Yes
UV mapping time	6 minutes 30 seconds
UV mapping memory usage	4.94 GB
Blending time	12 seconds
Blending memory usage	1.50 GB
Blending GPU memory usage	940.94 MB
Date created	2022:09:27 12:31:33
Software version	1.7.3.12426
File size	118.66 MB
<b>System</b>	
Software name	Agisoft Metashape Professional
Software version	1.7.3 build 12426
OS	Windows 64 bit
RAM	63.68 GB
CPU	Intel(R) Xeon(R) W-2145 CPU @ 3.70GHz
GPU(s)	NVIDIA GeForce RTX 2080 Ti

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# Survey Data

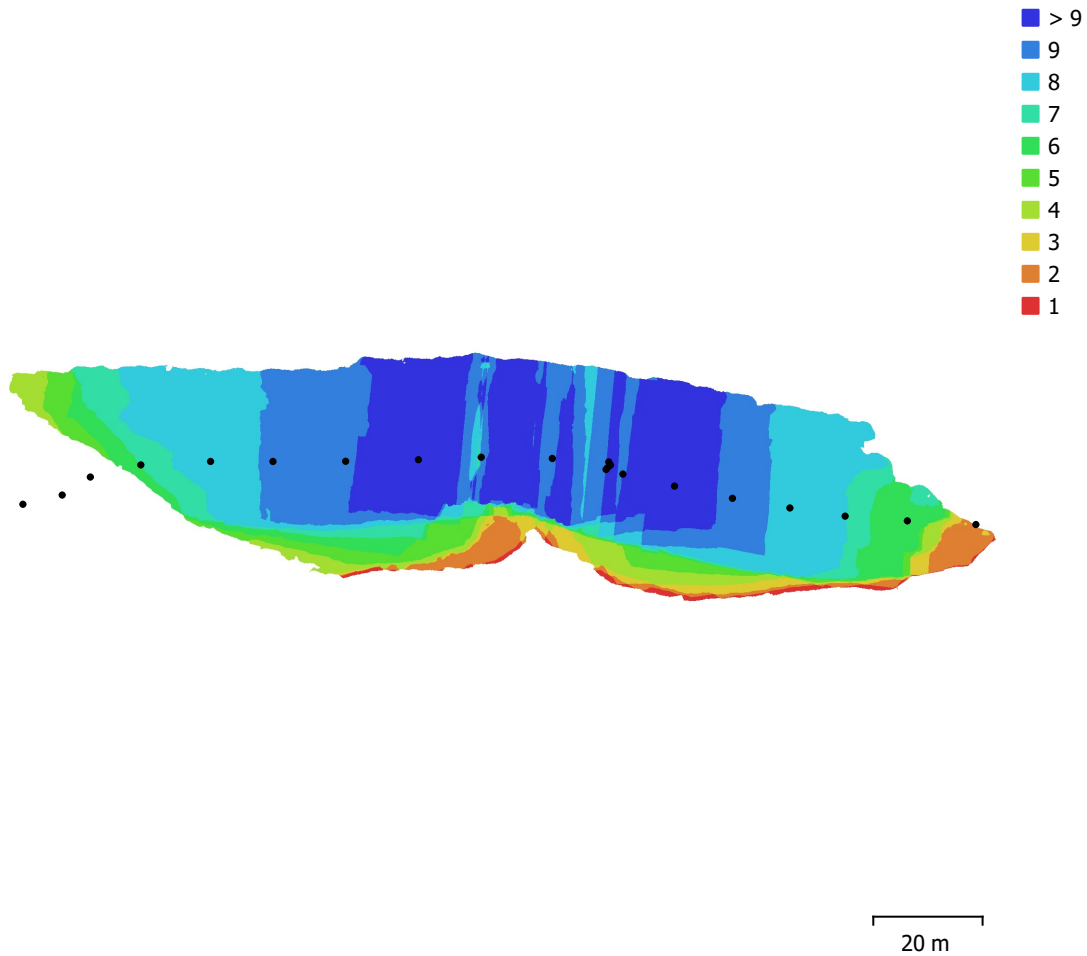


Fig. 1. Camera locations and image overlap.

Number of images:	21	Camera stations:	21
Flying altitude:	49.3 m	Tie points:	26,742
Ground resolution:	1.6 cm/pix	Projections:	70,449
Coverage area:	5.28e+03 m <sup>2</sup>	Reprojection error:	0.454 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC330 (3.61mm)	4000 x 3000	3.61 mm	1.56 x 1.56 μm	No

Table 1. Cameras.

# Camera Calibration

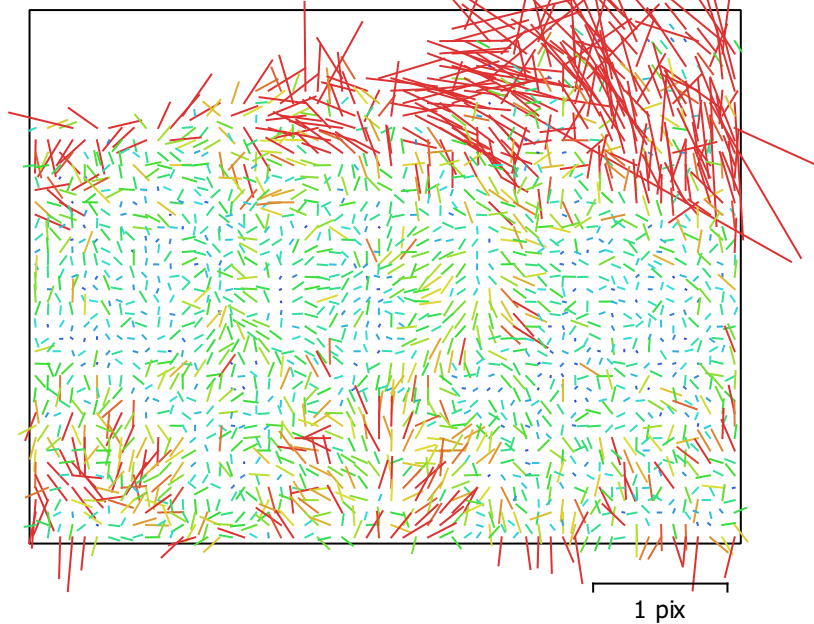


Fig. 2. Image residuals for FC330 (3.61mm).

## FC330 (3.61mm)

21 images

Type  
Frame

Resolution  
**4000 x 3000**

Focal Length  
**3.61 mm**

Pixel Size  
**1.56 x 1.56  $\mu$ m**

	Value	Error	F	Cx	Cy	K1	K2	K3	P1	P2
<b>F</b>	<b>2337.24</b>	0.2	1.00	-0.14	-0.13	-0.02	0.11	-0.11	-0.03	-0.15
<b>Cx</b>	<b>-15.7901</b>	0.43		1.00	0.06	-0.06	0.02	-0.03	0.96	0.04
<b>Cy</b>	<b>4.93166</b>	0.21			1.00	-0.04	-0.02	0.01	0.05	0.78
<b>K1</b>	<b>-0.00242617</b>	0.0001				1.00	-0.92	0.85	-0.04	-0.12
<b>K2</b>	<b>-0.00386654</b>	0.00022					1.00	-0.98	0.02	0.01
<b>K3</b>	<b>0.00165279</b>	0.00014						1.00	-0.02	-0.02
<b>P1</b>	<b>-0.000398155</b>	4.2e-05							1.00	0.02
<b>P2</b>	<b>-6.10738e-05</b>	1.6e-05								1.00

Table 2. Calibration coefficients and correlation matrix.



# Camera Locations

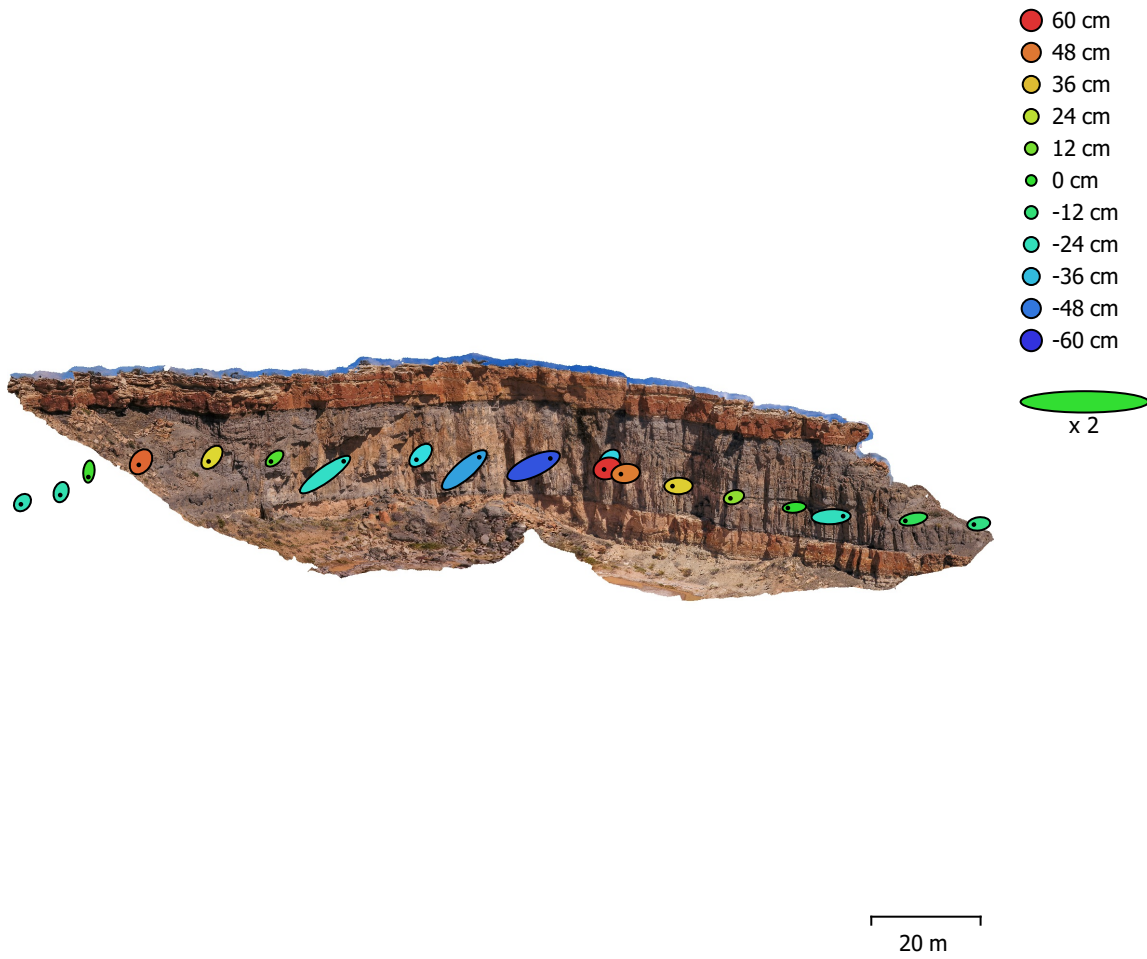


Fig. 3. Camera locations and error estimates.

Z error is represented by ellipse color. X,Y errors are represented by ellipse shape. Estimated camera locations are marked with a black dot.

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
1.42735	0.89997	0.313727	1.68739	1.7163

Table 3. Average camera location error.  
X - Longitude, Y - Latitude, Z - Altitude.

# Digital Elevation Model

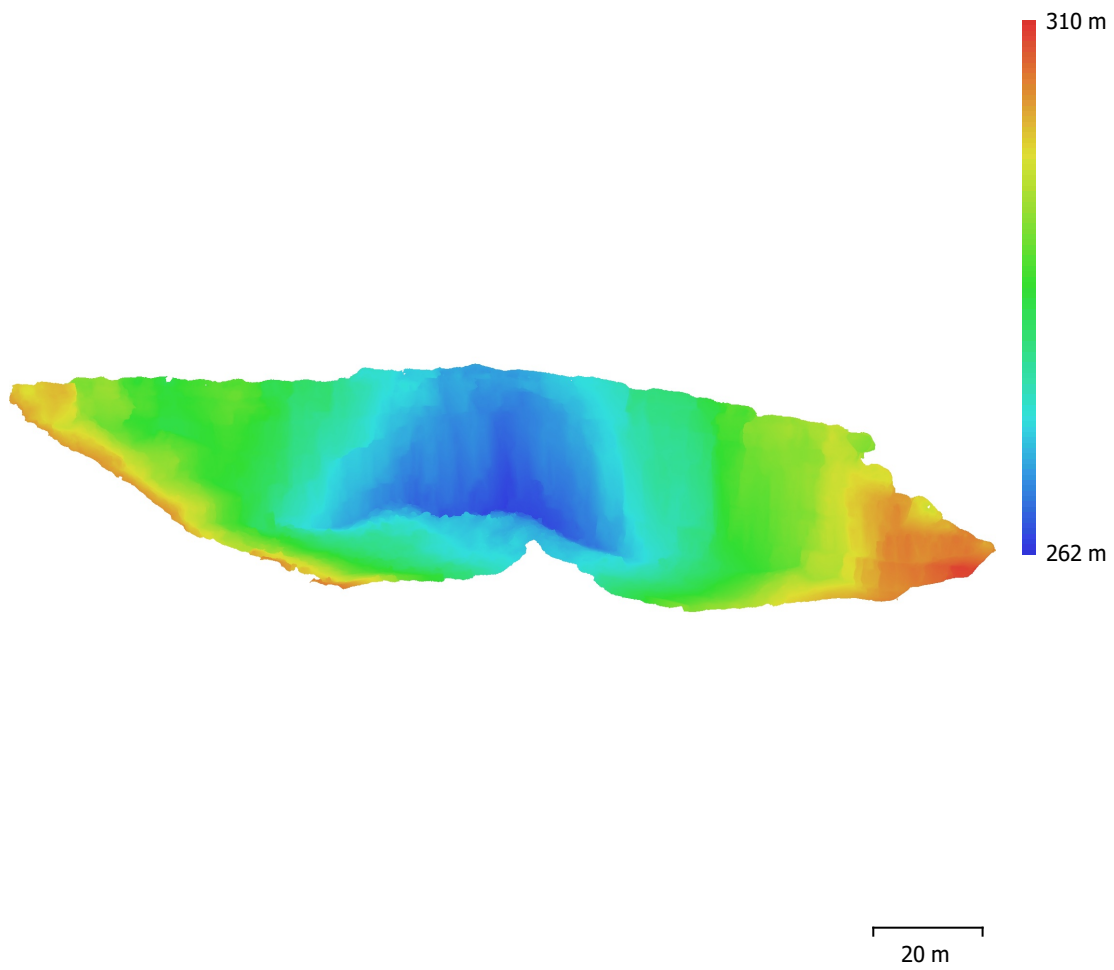


Fig. 4. Reconstructed digital elevation model.

Resolution: 3.21 cm/pix  
Point density: 973 points/m<sup>2</sup>

# Processing Parameters

## General

Cameras	21
Aligned cameras	21
Coordinate system	WGS 84 (EPSG::4326)
Rotation angles	Yaw, Pitch, Roll

## Point Cloud

Points	26,742 of 33,944
RMS reprojection error	0.131432 (0.453517 pix)
Max reprojection error	0.399997 (7.53553 pix)
Mean key point size	3.36082 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	2.71261

## Alignment parameters

Accuracy	High
Generic preselection	Yes
Reference preselection	Source
Key point limit	20,000
Key point limit per Mpx	1,000
Tie point limit	0
Exclude stationary tie points	Yes
Guided image matching	No
Adaptive camera model fitting	No
Matching time	41 seconds
Matching memory usage	291.38 MB
Alignment time	9 seconds
Alignment memory usage	13.57 MB
Date created	2022:09:21 11:37:54
Software version	1.7.3.12426
File size	2.12 MB

## Depth Maps

Count	21
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Moderate
Processing time	21 seconds
Memory usage	955.98 MB
Date created	2022:09:21 11:46:40
Software version	1.7.3.12426
File size	56.38 MB

## Dense Point Cloud

Points	8,313,260
Point colors	3 bands, uint8

## Depth maps generation parameters

Quality	High
Filtering mode	Moderate
Processing time	21 seconds
Memory usage	955.98 MB

## Dense cloud generation parameters

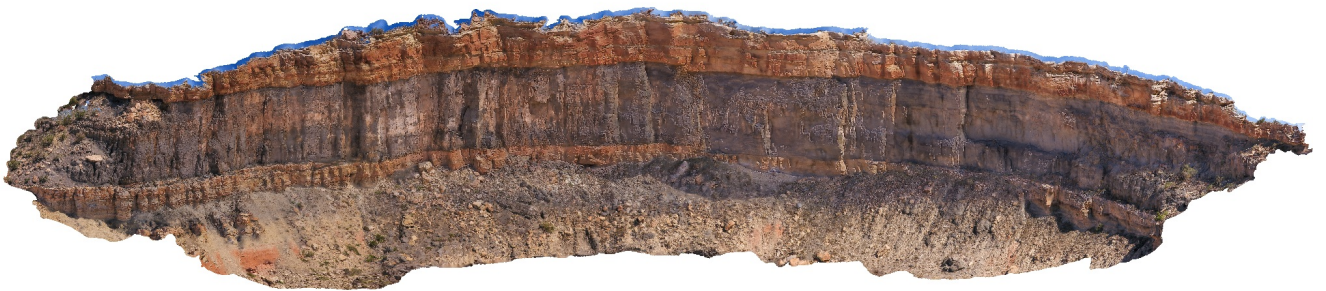
Processing time	27 seconds
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Memory usage	2.57 GB
Date created	2022:09:21 11:47:08
Software version	1.7.3.12426
File size	108.09 MB
<b>Model</b>	
Faces	1,642,056
Vertices	824,038
Vertex colors	3 bands, uint8
Texture	4,096 x 4,096, 4 bands, uint8
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Moderate
Processing time	21 seconds
Memory usage	955.98 MB
<b>Reconstruction parameters</b>	
Surface type	Arbitrary
Source data	Dense cloud
Interpolation	Enabled
Strict volumetric masks	No
Processing time	4 minutes 20 seconds
Memory usage	4.54 GB
<b>Texturing parameters</b>	
Mapping mode	Generic
Blending mode	Mosaic
Texture size	4,096
Enable hole filling	Yes
Enable ghosting filter	Yes
UV mapping time	2 minutes 37 seconds
UV mapping memory usage	4.25 GB
Blending time	11 seconds
Blending memory usage	1.48 GB
Blending GPU memory usage	920.45 MB
Date created	2022:09:21 11:48:29
Software version	1.7.3.12426
File size	103.21 MB
<b>System</b>	
Software name	Agisoft Metashape Professional
Software version	1.7.3 build 12426
OS	Windows 64 bit
RAM	63.68 GB
CPU	Intel(R) Xeon(R) W-2145 CPU @ 3.70GHz
GPU(s)	NVIDIA GeForce RTX 2080 Ti

# Agisoft Metashape

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# Survey Data

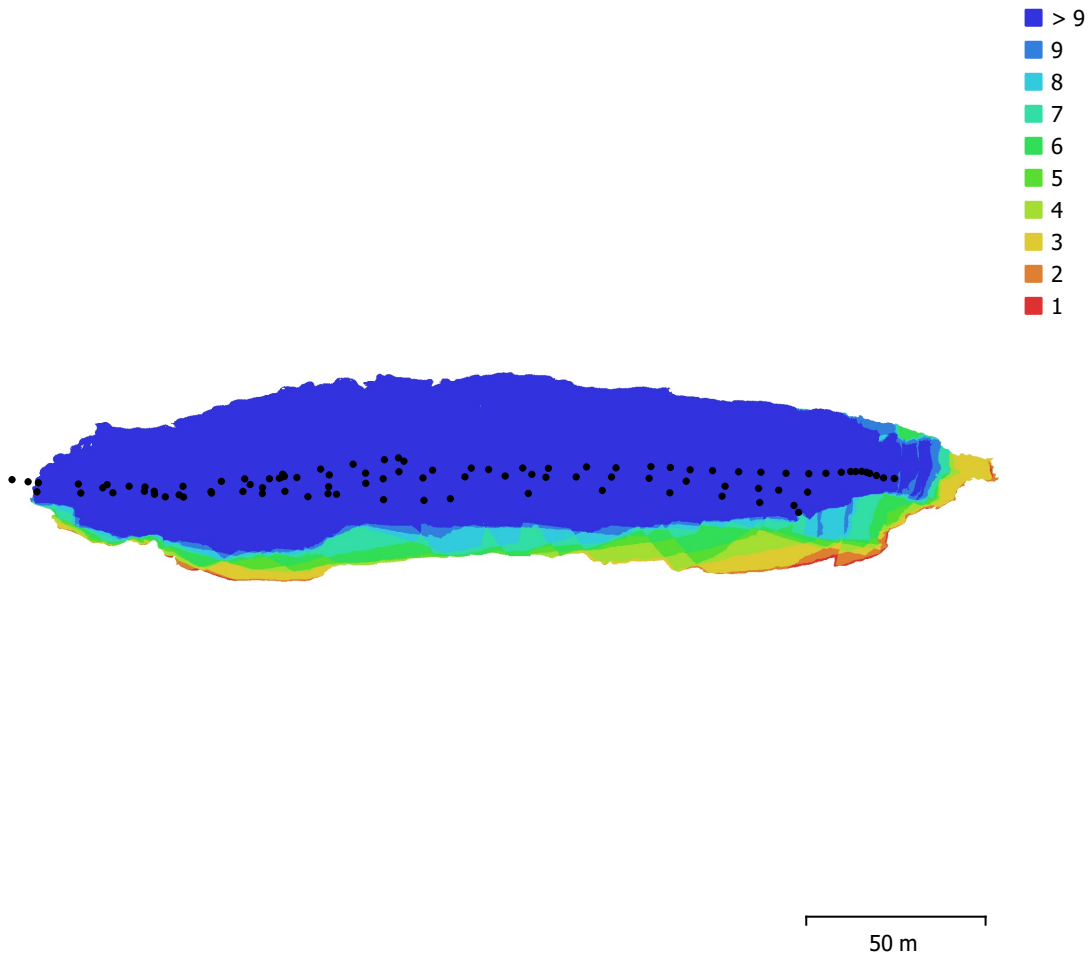


Fig. 1. Camera locations and image overlap.

Number of images:	96	Camera stations:	96
Flying altitude:	35.5 m	Tie points:	142,872
Ground resolution:	1.37 cm/pix	Projections:	356,058
Coverage area:	0.0112 km <sup>2</sup>	Reprojection error:	0.571 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC330 (3.61mm)	4000 x 3000	3.61 mm	1.56 x 1.56 $\mu$ m	No

Table 1. Cameras.

# Camera Calibration

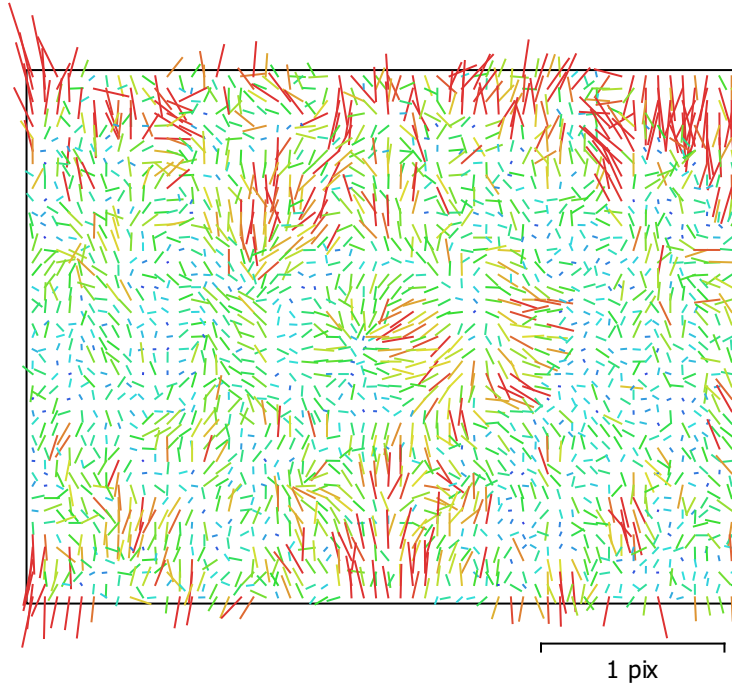


Fig. 2. Image residuals for FC330 (3.61mm).

## FC330 (3.61mm)

96 images

Type	Resolution	Focal Length	Pixel Size
<b>Frame</b>	<b>4000 x 3000</b>	<b>3.61 mm</b>	<b>1.56 x 1.56 μm</b>

	Value	Error	F	Cx	Cy	K1	K2	K3	P1	P2
<b>F</b>	<b>2339.12</b>	0.11	1.00	-0.19	-0.30	0.11	0.08	-0.09	-0.21	-0.17
<b>Cx</b>	<b>-9.69133</b>	0.24		1.00	0.06	-0.04	0.02	-0.02	0.97	0.06
<b>Cy</b>	<b>1.43184</b>	0.13			1.00	-0.08	0.02	-0.01	0.06	0.85
<b>K1</b>	<b>-0.00311351</b>	5.7e-05				1.00	-0.93	0.86	-0.04	-0.07
<b>K2</b>	<b>-0.00243044</b>	0.00012					1.00	-0.98	0.02	0.01
<b>K3</b>	<b>0.000617723</b>	7.4e-05						1.00	-0.02	-0.00
<b>P1</b>	<b>0.000223938</b>	2.4e-05							1.00	0.06
<b>P2</b>	<b>7.39291e-05</b>	1e-05								1.00

Table 2. Calibration coefficients and correlation matrix.

# Camera Locations

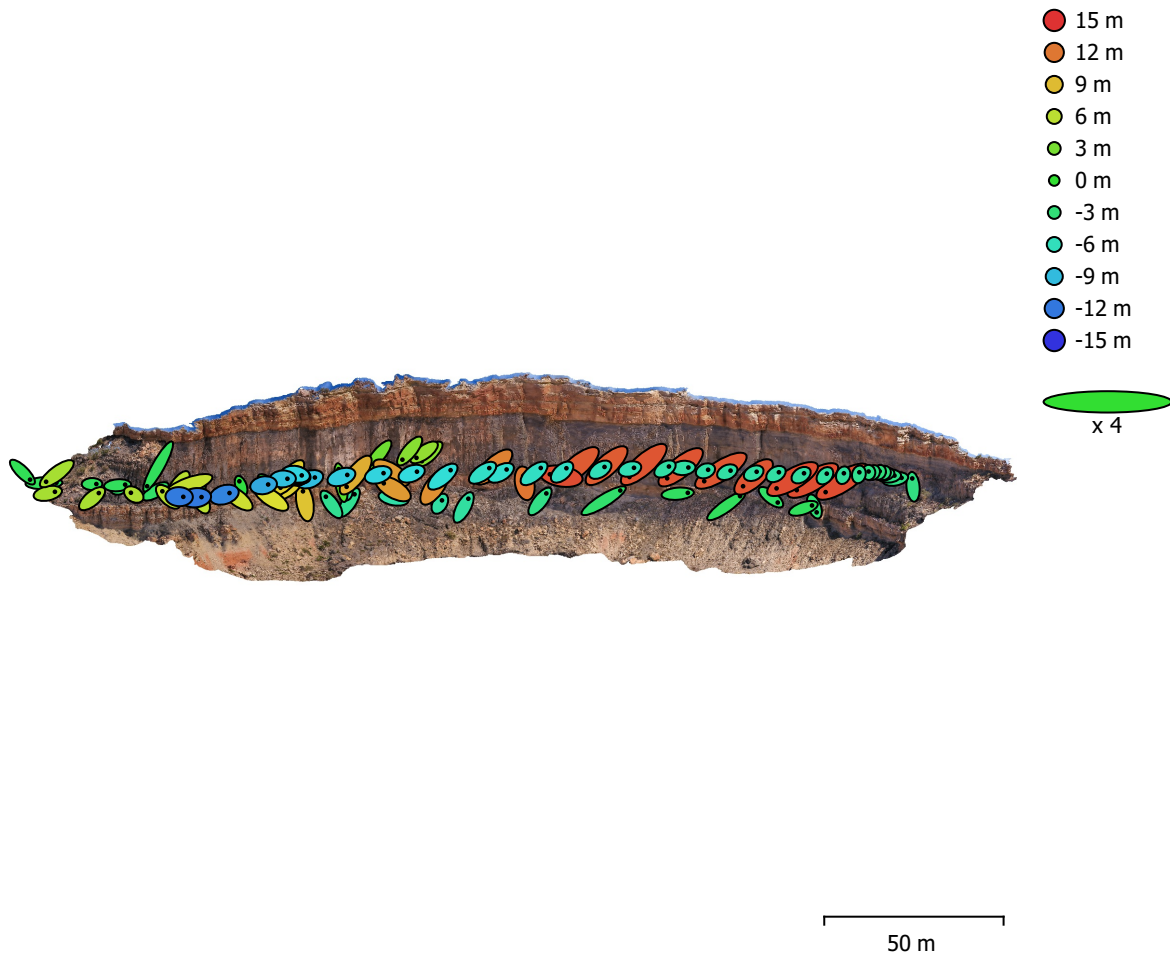


Fig. 3. Camera locations and error estimates.

Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.

Estimated camera locations are marked with a black dot.

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
1.07335	0.897378	7.30217	1.39906	7.43499

Table 3. Average camera location error.

X - Longitude, Y - Latitude, Z - Altitude.



# Digital Elevation Model

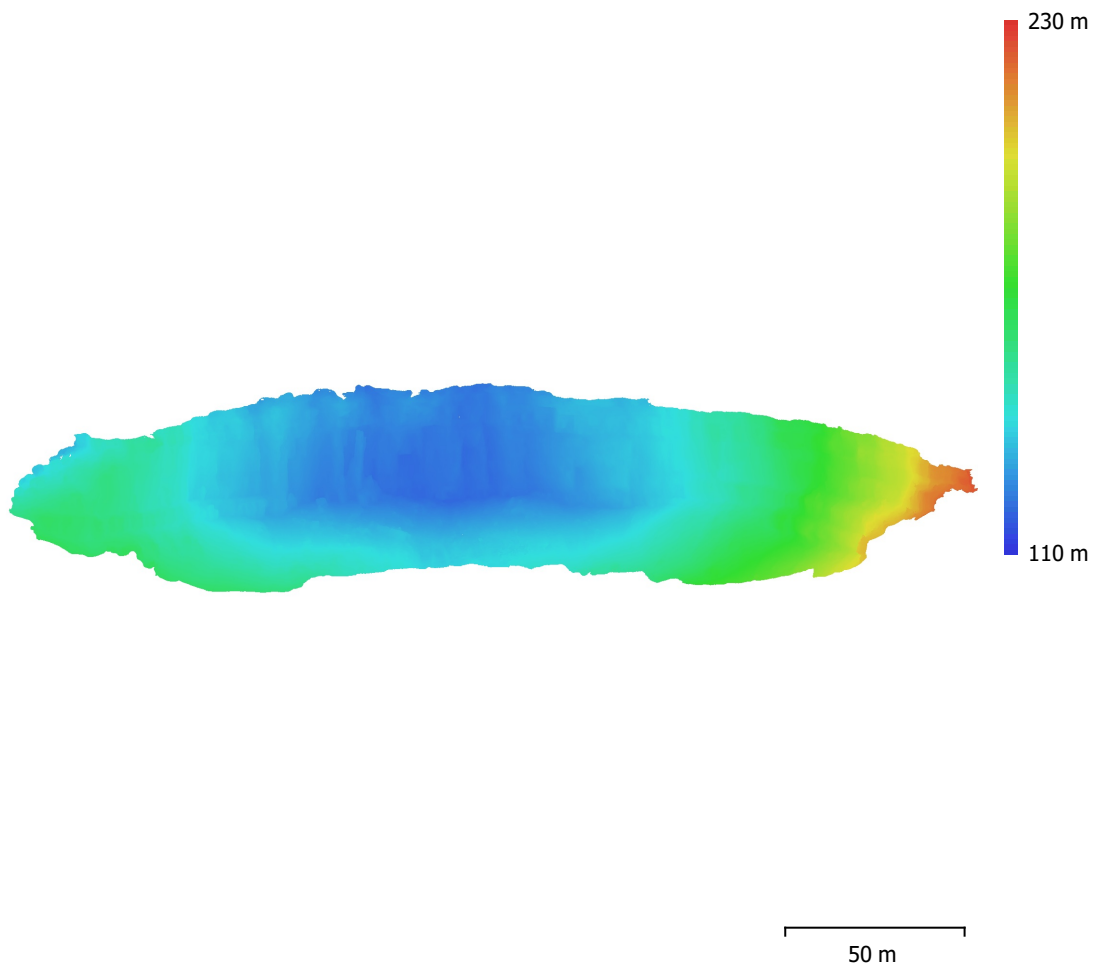


Fig. 4. Reconstructed digital elevation model.

Resolution: 2.75 cm/pix  
Point density: 0.133 points/cm<sup>2</sup>

# Processing Parameters

## General

Cameras	96
Aligned cameras	96
Coordinate system	WGS 84 (EPSG::4326)
Rotation angles	Yaw, Pitch, Roll

## Point Cloud

Points	142,872 of 173,491
RMS reprojection error	0.150982 (0.5711 pix)
Max reprojection error	0.399995 (8.19238 pix)
Mean key point size	3.60104 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	2.74286

## Alignment parameters

Accuracy	High
Generic preselection	Yes
Reference preselection	Source
Key point limit	20,000
Key point limit per Mpx	1,000
Tie point limit	0
Exclude stationary tie points	Yes
Guided image matching	No
Adaptive camera model fitting	No
Matching time	25 seconds
Matching memory usage	527.55 MB
Alignment time	48 seconds
Alignment memory usage	87.29 MB
Date created	2022:10:04 12:34:21
Software version	1.7.3.12426
File size	11.04 MB

## Depth Maps

Count	96
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	1 minutes 39 seconds
File size	318.86 MB

## Dense Point Cloud

Points	28,879,945
Point colors	3 bands, uint8
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	1 minutes 39 seconds
<b>Dense cloud generation parameters</b>	
Processing time	6 minutes 23 seconds
Date created	2022:10:04 12:46:59
Software version	1.7.3.12426
File size	372.84 MB

## Model

Faces	5,399,181
Vertices	2,705,490
Vertex colors	3 bands, uint8
Texture	4,096 x 4,096, 4 bands, uint8
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	1 minutes 39 seconds
<b>Reconstruction parameters</b>	
Surface type	Arbitrary
Source data	Dense cloud
Interpolation	Enabled
Strict volumetric masks	No
Processing time	14 minutes 50 seconds
Memory usage	14.97 GB
<b>Texturing parameters</b>	
Mapping mode	Generic
Blending mode	Mosaic
Texture size	4,096
Enable hole filling	Yes
Enable ghosting filter	Yes
UV mapping time	5 minutes 41 seconds
UV mapping memory usage	4.66 GB
Blending time	30 seconds
Blending memory usage	2.06 GB
Blending GPU memory usage	1.10 GB
Date created	2022:10:04 12:47:56
Software version	1.7.3.12426
File size	263.45 MB
<b>System</b>	
Software name	Agisoft Metashape Professional
Software version	1.7.3 build 12426
OS	Windows 64 bit
RAM	63.68 GB
CPU	Intel(R) Xeon(R) W-2145 CPU @ 3.70GHz
GPU(s)	NVIDIA GeForce RTX 2080 Ti

# Agisoft Metashape

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# Survey Data

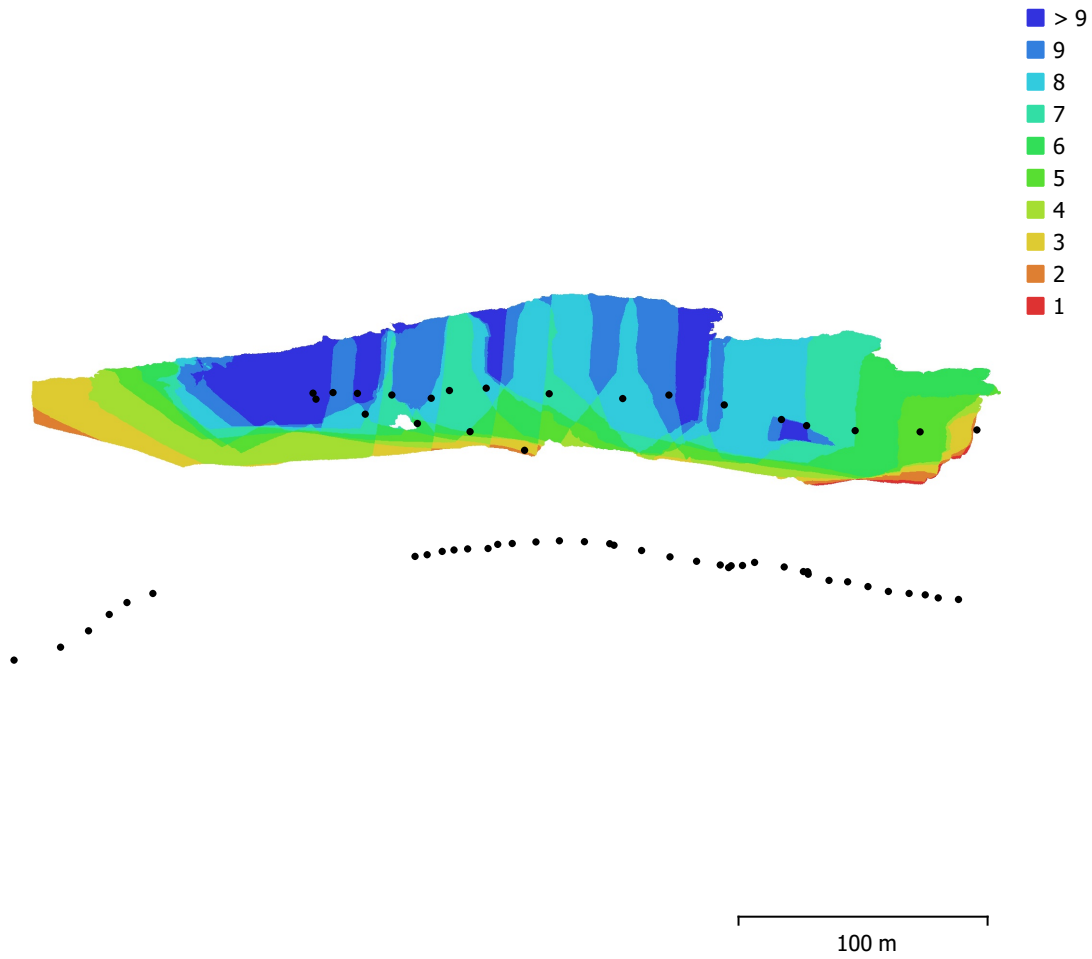


Fig. 1. Camera locations and image overlap.

Number of images:	62	Camera stations:	61
Flying altitude:	59.2 m	Tie points:	72,660
Ground resolution:	1.97 cm/pix	Projections:	177,259
Coverage area:	0.0186 km <sup>2</sup>	Reprojection error:	0.512 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC330 (3.61mm)	4000 x 3000	3.61 mm	1.56 x 1.56 $\mu$ m	No

Table 1. Cameras.

# Camera Calibration

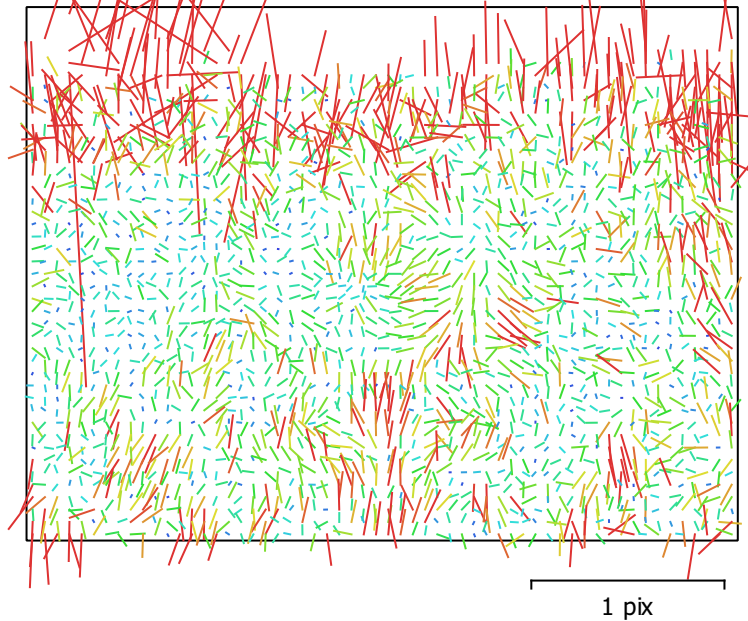


Fig. 2. Image residuals for FC330 (3.61mm).

## FC330 (3.61mm)

62 images

Type  
Frame

Resolution  
**4000 x 3000**

Focal Length  
**3.61 mm**

Pixel Size  
**1.56 x 1.56  $\mu\text{m}$**

	Value	Error	F	Cx	Cy	K1	K2	K3	P1	P2
<b>F</b>	<b>2336.98</b>	0.19	1.00	-0.04	-0.33	0.25	0.06	-0.07	-0.10	-0.33
<b>Cx</b>	<b>-7.24443</b>	0.4		1.00	-0.05	0.06	-0.01	-0.01	0.97	-0.09
<b>Cy</b>	<b>-7.98932</b>	0.21			1.00	-0.13	-0.02	0.01	-0.03	0.87
<b>K1</b>	<b>-0.00240448</b>	8.8e-05				1.00	-0.86	0.79	0.07	-0.20
<b>K2</b>	<b>-0.0036353</b>	0.00017					1.00	-0.98	-0.01	-0.00
<b>K3</b>	<b>0.00137966</b>	0.00011						1.00	-0.00	-0.00
<b>P1</b>	<b>0.000501599</b>	3.9e-05							1.00	-0.08
<b>P2</b>	<b>-0.000395028</b>	1.8e-05								1.00

Table 2. Calibration coefficients and correlation matrix.

# Camera Locations

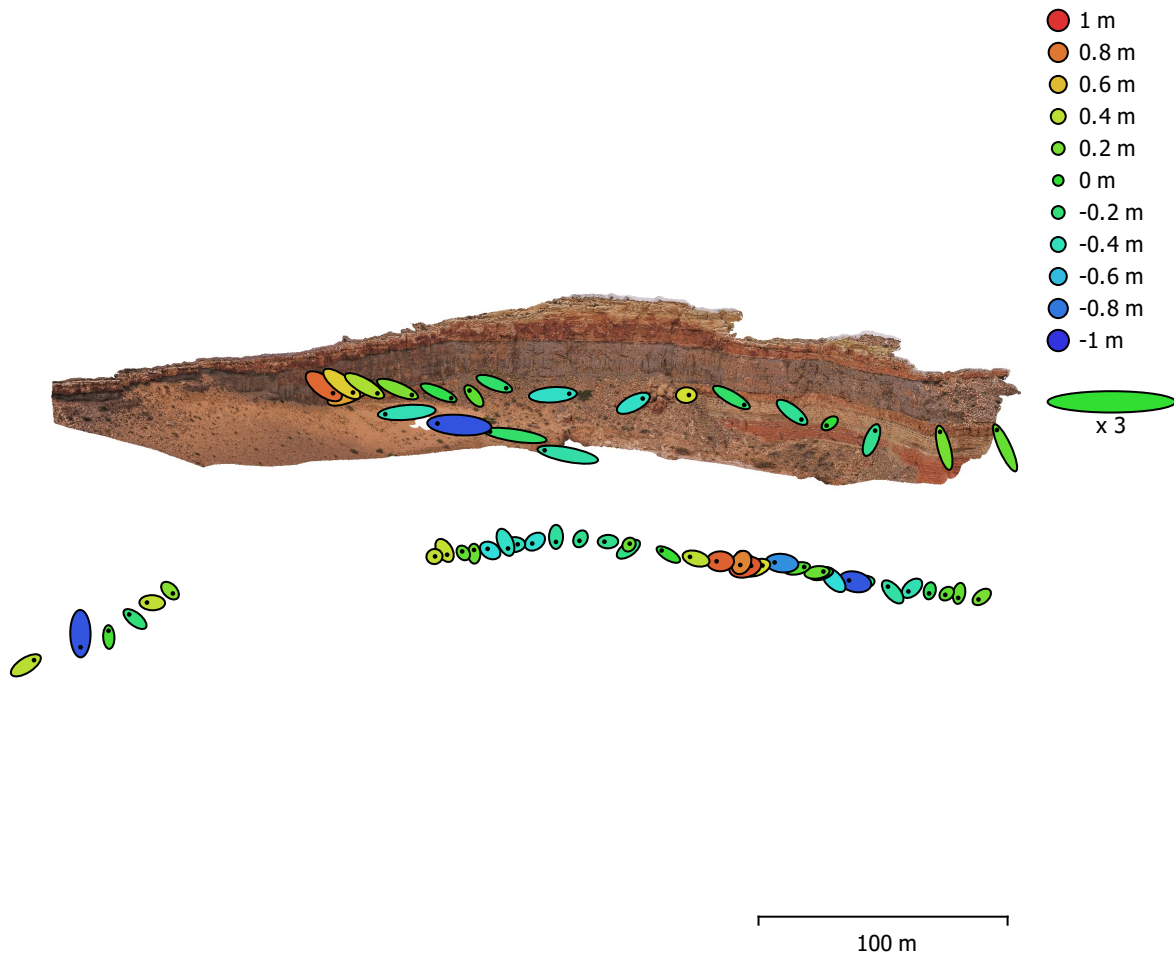


Fig. 3. Camera locations and error estimates.

Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.

Estimated camera locations are marked with a black dot.

X error (m)	Y error (m)	Z error (m)	XY error (m)	Total error (m)
2.35535	1.42707	0.432285	2.75394	2.78766

Table 3. Average camera location error.

X - Longitude, Y - Latitude, Z - Altitude.

# Digital Elevation Model

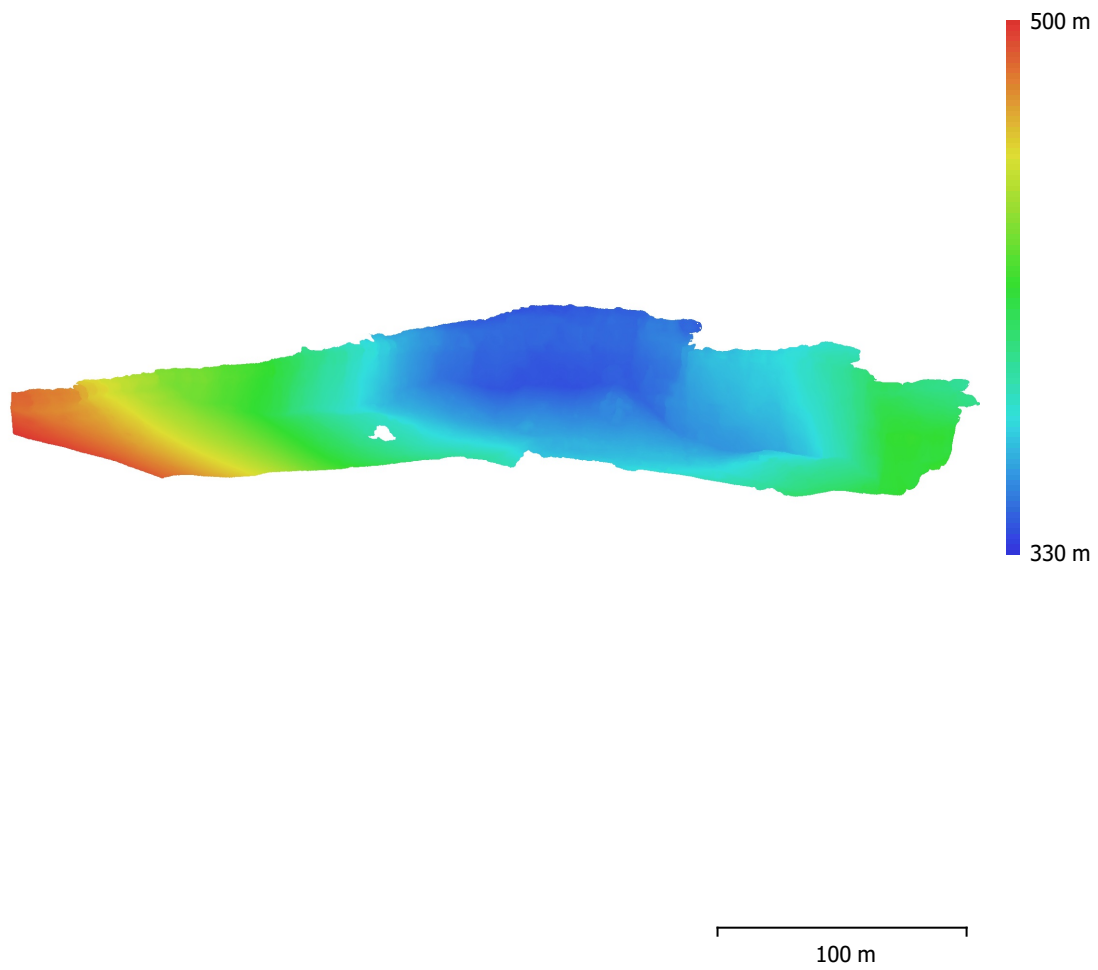


Fig. 4. Reconstructed digital elevation model.

Resolution: 3.94 cm/pix  
Point density: 645 points/m<sup>2</sup>



# Processing Parameters

## General

Cameras	62
Aligned cameras	61
Coordinate system	WGS 84 (EPSG::4326)
Rotation angles	Yaw, Pitch, Roll

## Point Cloud

Points	72,660 of 94,080
RMS reprojection error	0.137292 (0.512399 pix)
Max reprojection error	0.399963 (8.39175 pix)
Mean key point size	3.59316 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	2.64538

## Alignment parameters

Accuracy	High
Generic preselection	Yes
Reference preselection	Source
Key point limit	20,000
Key point limit per Mpx	1,000
Tie point limit	0
Exclude stationary tie points	Yes
Guided image matching	No
Adaptive camera model fitting	No
Matching time	15 seconds
Matching memory usage	397.01 MB
Alignment time	38 seconds
Alignment memory usage	56.07 MB
Date created	2022:10:04 10:27:24
Software version	1.7.3.12426
File size	5.74 MB

## Depth Maps

Count	61
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### Depth maps generation parameters

Quality	High
Filtering mode	Mild
Processing time	58 seconds
File size	147.10 MB

## Dense Point Cloud

Points	35,408,025
Point colors	3 bands, uint8

### Depth maps generation parameters

Quality	High
Filtering mode	Mild
Processing time	58 seconds

### Dense cloud generation parameters

Processing time	1 minutes 52 seconds
Date created	2022:10:04 10:38:34
Software version	1.7.3.12426
File size	460.54 MB

## Model

Faces	3,669,009
Vertices	1,839,719
Vertex colors	3 bands, uint8
Texture	4,096 x 4,096, 4 bands, uint8
<b>Depth maps generation parameters</b>	
Quality	High
Filtering mode	Mild
Processing time	58 seconds
<b>Reconstruction parameters</b>	
Surface type	Arbitrary
Source data	Dense cloud
Interpolation	Enabled
Strict volumetric masks	No
Processing time	18 minutes 40 seconds
Memory usage	18.98 GB
<b>Texturing parameters</b>	
Mapping mode	Generic
Blending mode	Mosaic
Texture size	4,096
Enable hole filling	Yes
Enable ghosting filter	Yes
UV mapping time	4 minutes 52 seconds
UV mapping memory usage	5.07 GB
Blending time	13 seconds
Blending memory usage	1.85 GB
Blending GPU memory usage	1.01 GB
Date created	2022:10:04 10:39:01
Software version	1.7.3.12426
File size	187.19 MB
<b>System</b>	
Software name	Agisoft Metashape Professional
Software version	1.7.3 build 12426
OS	Windows 64 bit
RAM	63.68 GB
CPU	Intel(R) Xeon(R) W-2145 CPU @ 3.70GHz
GPU(s)	NVIDIA GeForce RTX 2080 Ti