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Title: Montage (stitched 20X images) Pit Assessment of FY16 DE05

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Montage (stitched 20X images) Pit Assessment of FY16 DE05

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NNSA
National Nuclear Security Administration

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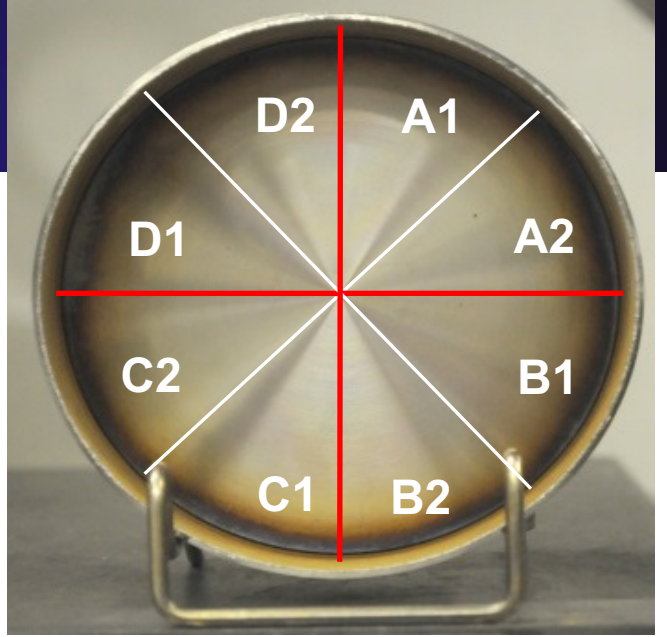
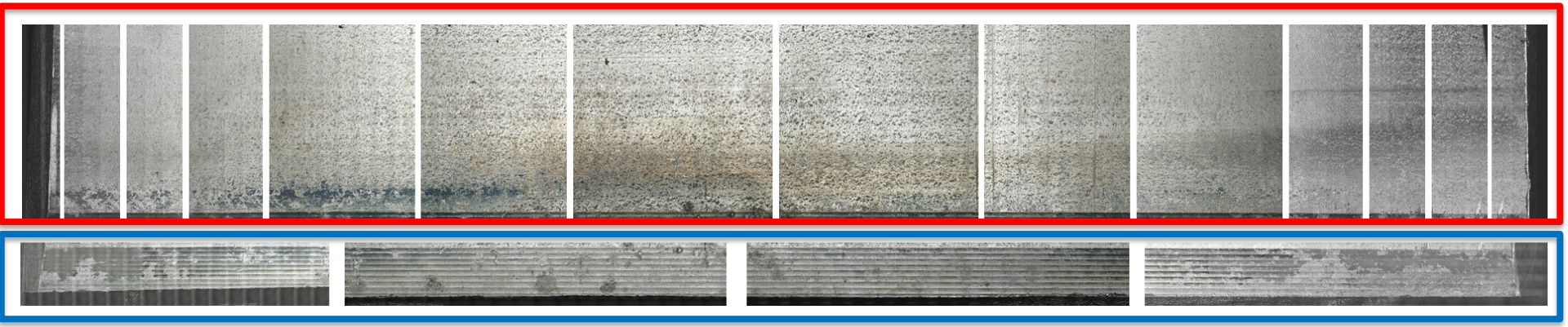
Montage (Stitched) Analysis for Zone 3 Sections 1-14 (Sub-subsections)

Four Sections: A-D (cut lid in quarters)
8 Subsections: A1 – D2 (cut section in half)
14 Sub-subsections in Zone 3: 1-14 (scanning areas set to reduce curvature)
4 Sub-subsections in Zone 1&2: a-d
One montage image per sub-subsection



Zone 3: 14 sections (sub-subsections)



Zone 1 & 2 : 4 sections (sub-subsections)

Montage (Stitched) Image versus 20X LCM images

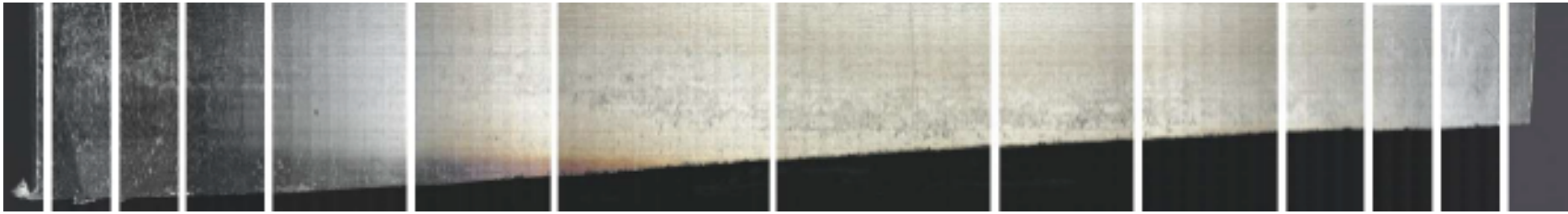
- 20X LCM higher resolution than montage (stitched) images
  - 20X LCM pixel is 0.7 microns per side
  - Current montage specification results in pixels with between 2 and 5 microns per side

- Comparison to 20X LCM and Gwyddion analysis show that montage data analysis does a good job of capturing pit depths, area, volume and other statistics of interest

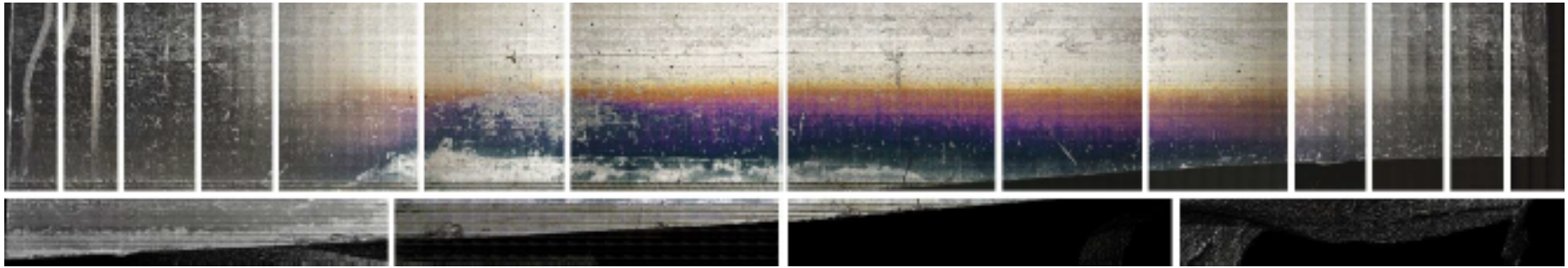
Automated Pit Analysis for FY16DE05 Stitched Images

For FY16 DE05 Sections D1 and D2 lost about 20% of the ICCWR during the weld removal process

D2 (All of Zone 1&2 was lost, dark area in zone 3 is off sample). D2 not used in analysis



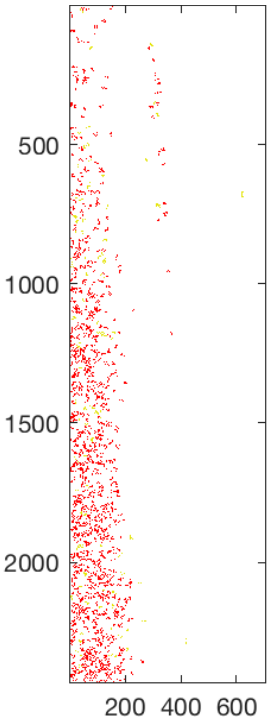
D1 (Part of Zone 1&2 and Zone 3 for Sections 9-14 [not used in analysis]



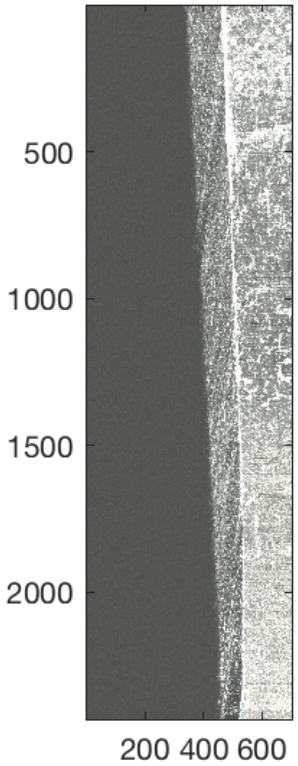
Note that edges (sub-subsections 1 and 14 have considerable area off sample and are not included in the automated analysis [analyzed individually])

Example of an edge image that was removed for automated analysis : B2 Section 1

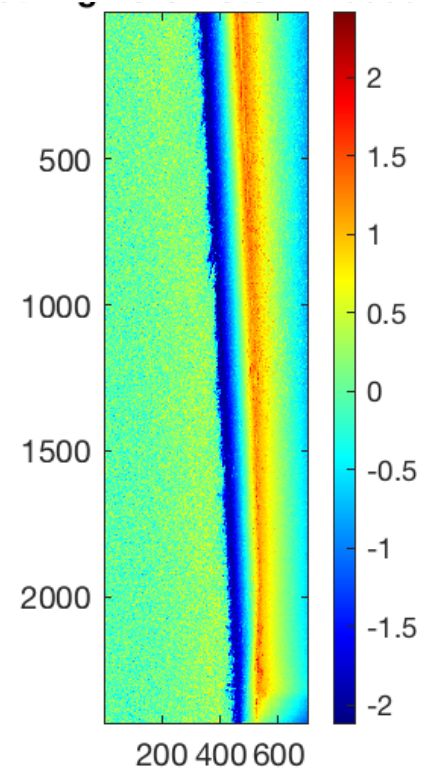
Flagged features



Laser Optical



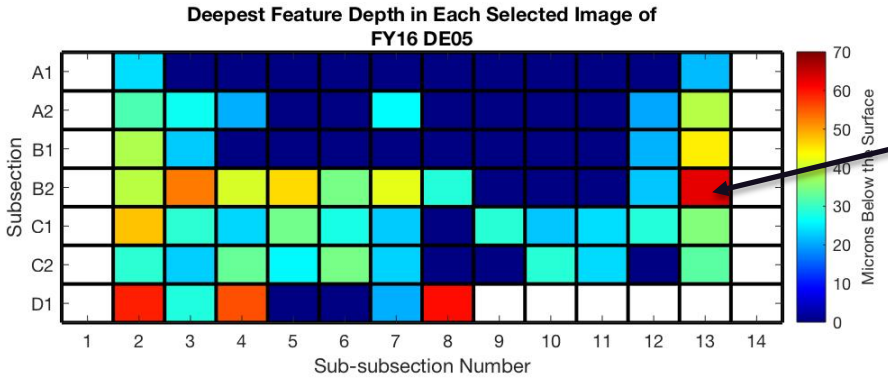
Height

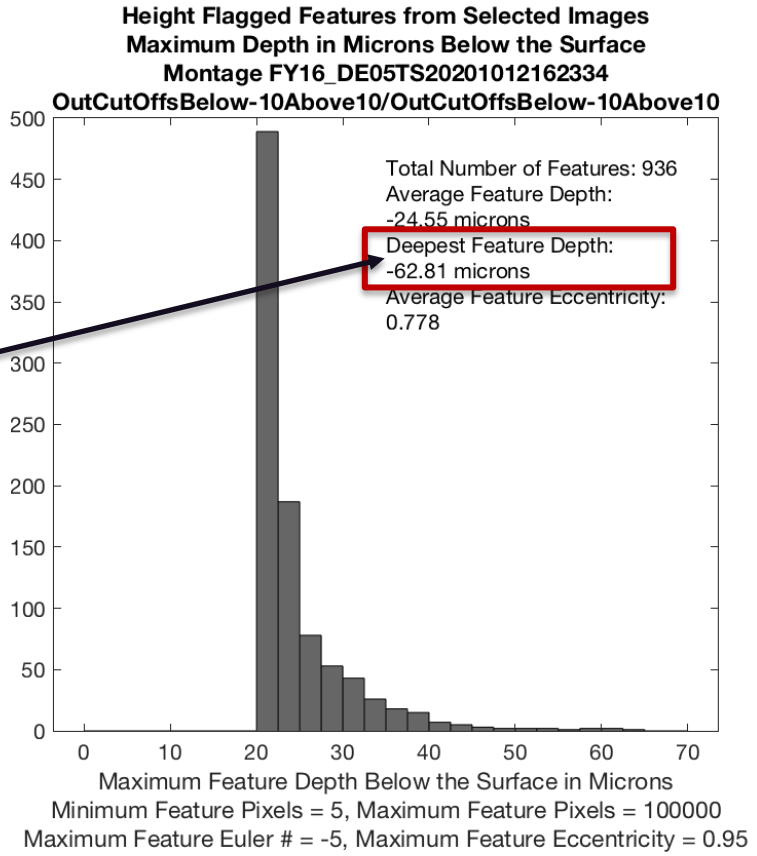


- Edge sections have black\dark grey areas.
- The black\dark grey areas are not on the sample. It means that the surface in that region is too deep or out of the height scanning range of the LCM.
- On edge sections (Section 1 and 14) most deep features are found in the off-sample area.
- These features can be over 100 microns deep and are not representative of the sample.

Height Data Summary- FY16 DE05 Zone 3

White areas are images that are not analyzed by automatic software





Pit rankings based upon depth and volume

imagename	Rank Volume	Rank Pit Depth	NumPixels	MaximumDepth Microns	LowVolumeMicronsCubed	CentroidRow	CentroidColumn
FY16_DE05_SW_B2_Zone_3_Section_13.vk4	8	1	21	-62.81314	-4930.32461	336.7619	749.1905
FY16_DE05_SW_D1_Zone_3_Section_8.vk4	3	2	60	-60.31078673	-53145.05713	1331.316667	1158.71667
FY16_DE05_SW_D1_Zone_3_Section_2.vk4	6	3	6	-58.9488149	-11094.17849	314.089744	577.5
FY16_DE05_SW_D1_Zone_3_Section_4.vk4	4	4	86	-55.63530687	-13936.37717	341.7093023	1255.74419
FY16_DE05_SW_B2_Zone_3_Section_3.vk4	1	5	446	-52.64095968	-70534.86766	393.9596413	1309.74215
FY16_DE05_SW_C1_Zone_3_Section_2.vk4	5	6	101	-47.74978182	-12077.00169	128.1386139	749.405941
FY16_DE05_SW_B2_Zone_3_Section_5.vk4	2	7	328	-46.03733633	-54755.16143	360.4054878	1412.14329
FY16_DE05_SW_B1_Zone_3_Section_13.vk4	7	8	31	-44.62994281	-5707.625063	601.6774194	896.064516

The deepest pits are not necessarily the ones with the greatest volume

In addition to table, software generates many feature statistics, eccentricity, area, number of holes (sponginess), average depth, perimeter.

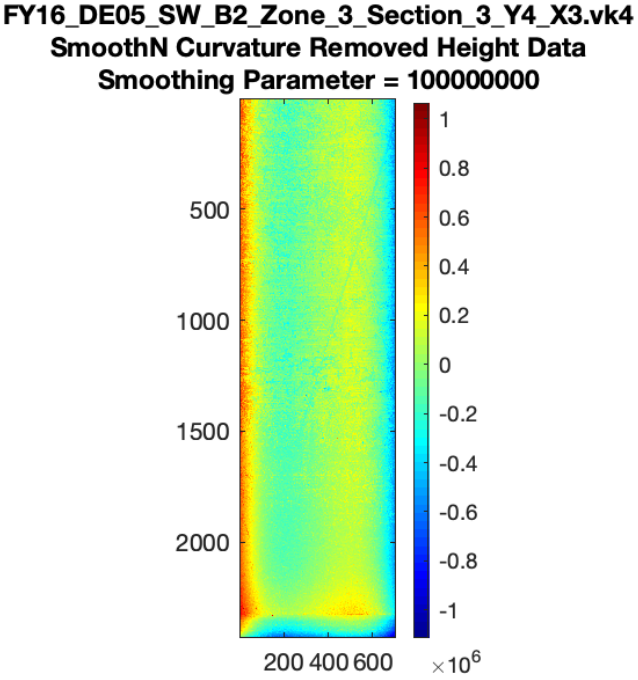
Flagged features

- The automated software flags features of interest as red, yellow, and green.
  - **Red features**: Depths 50 microns or more
  - **Yellow features**: Depths greater than 20 microns and less than 50 microns (*note these features are difficult to see on small plots*)
  - **Green**: Depths less than 20 microns.

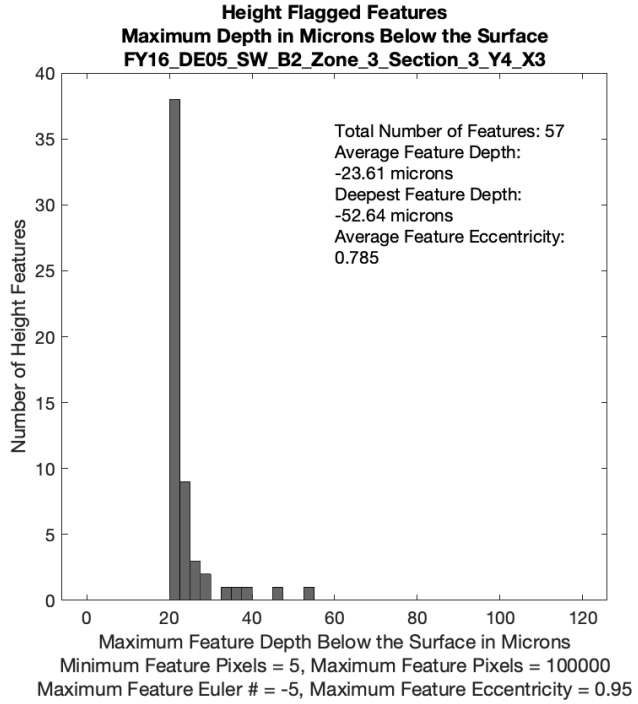
- Once the features are flagged by depth, they are ranked by volume to look at the largest features.

Pit Depth B2 Section 3 Histogram Height Data
Volume Ranking 1; Deepest Pit Ranking: 5

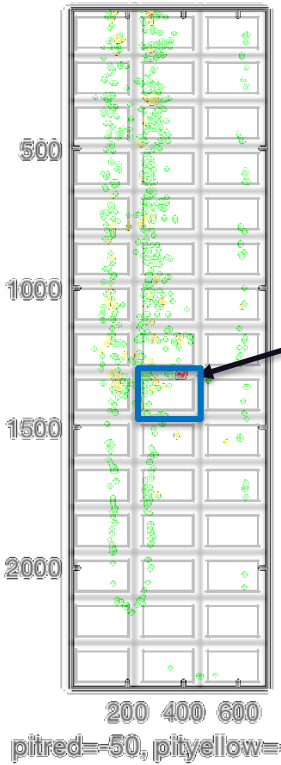
Flattened Height Data



Flagged Height Features



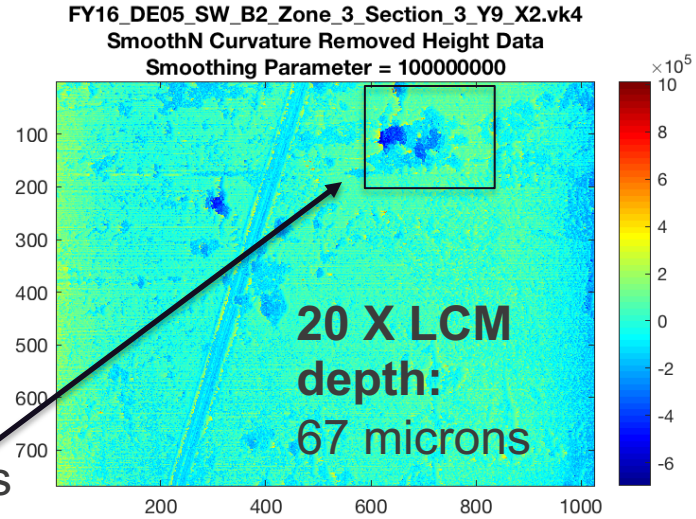
Detail for B2 Section 3, Volume Ranking 1; Deepest Pit Ranking: 5 (Can drill down to 20X Image)



Montage analysis results

NumPixels	MaximumDepth	LowVolumeMicronsCubed	CentroidRow	CentroidColumn
446	-52.64096	-70534.868	393.9596	1309.7422

There are 45 individual 20x (15 rows and 3 columns) images that make up the montage of B2 Section 3.



Individual 20X vk4 file results

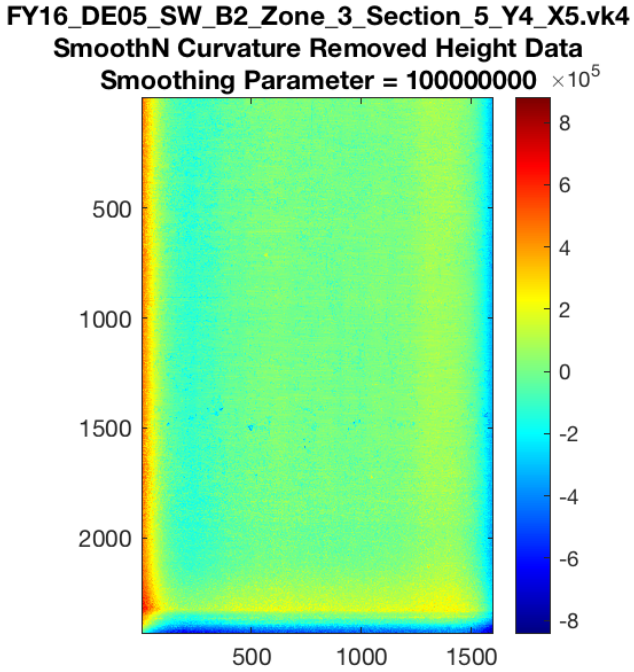
NumPixels	MaximumDepthMicrons	LowVolumeMicronsCubed	CentroidRow	CentroidColumn
6077	-67.387	-68318.32	676.711864	115.565246

Flagged Features

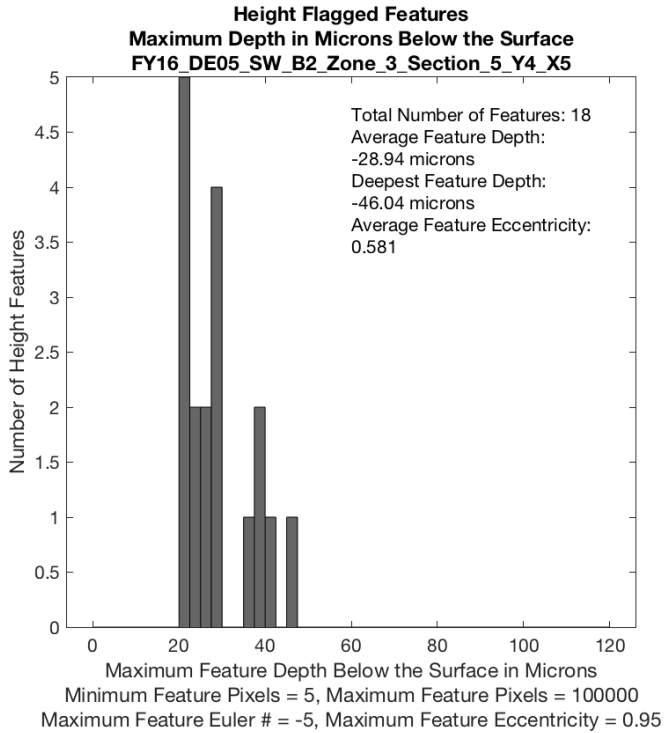
Red > 50 micron depth
Yellow <50, >20
Green <20, >10

Pit Depth B2 Section 5 Histogram Height Data
Volume ranking 2; Deepest Pit Ranking: 7

Flattened Height Data



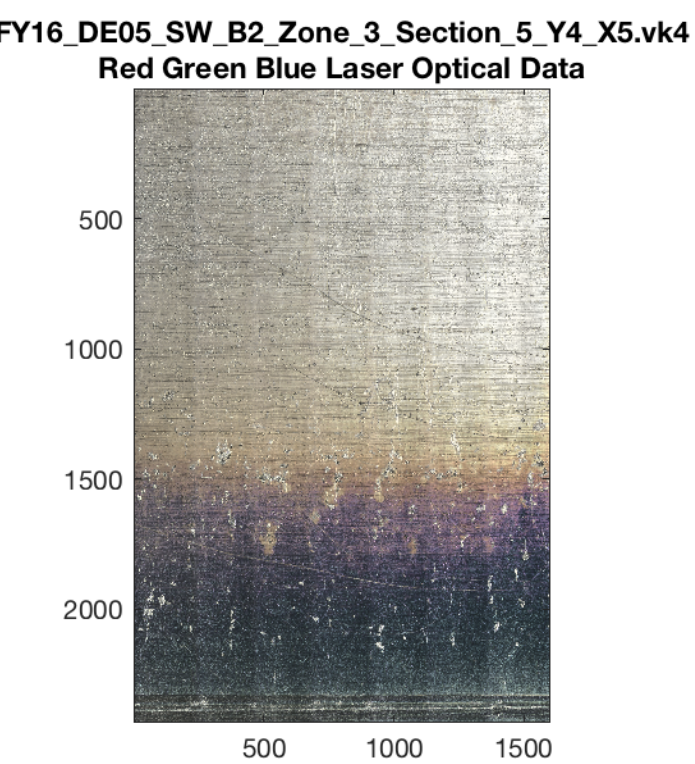
Flagged Height Features

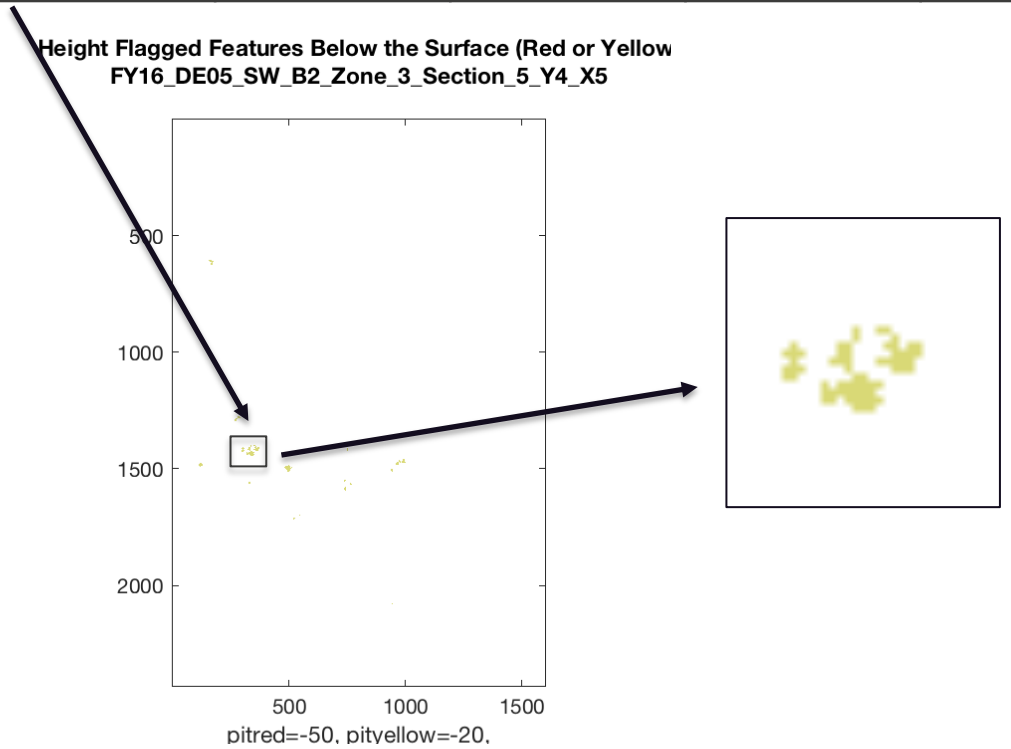


Detail for B2 Section 5
Volume ranking 2; Deepest Pit Ranking: 7

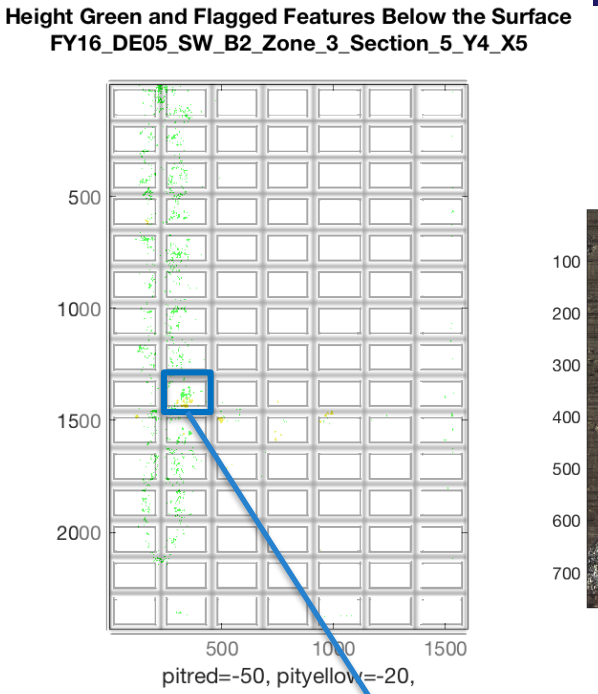
Montage is composed of 105 images (15 rows and 7 columns)

NumPixels	MaximumDepth	LowVolumeMicronsCubed	CentroidRow	CentroidColumn
328	-46.03734	-54755.1614	360.405488	1412.14329

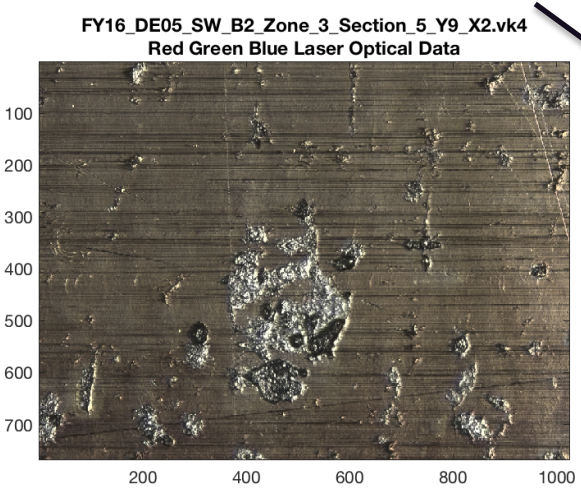


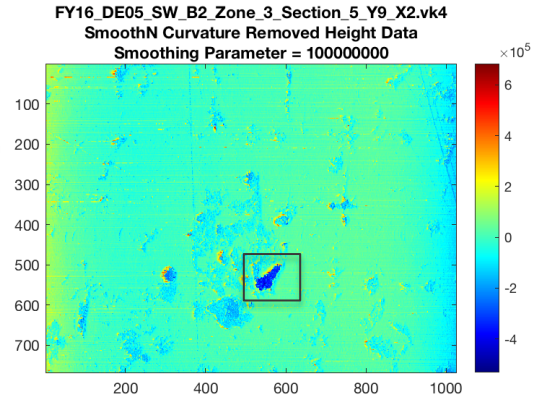


Individual vk4 file analysis of B2 Section 5 (different depths a result of montage smoothing)

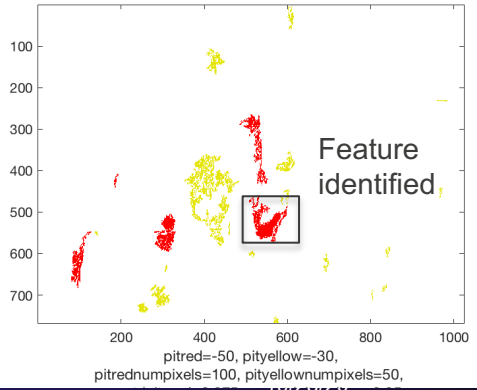


Num Pixels	Maximum Depth Microns	Low Volume Microns Cubed	Centroid Row	Centroid Column
3402	-52.776	-35719.7046	549.781893	524.137566



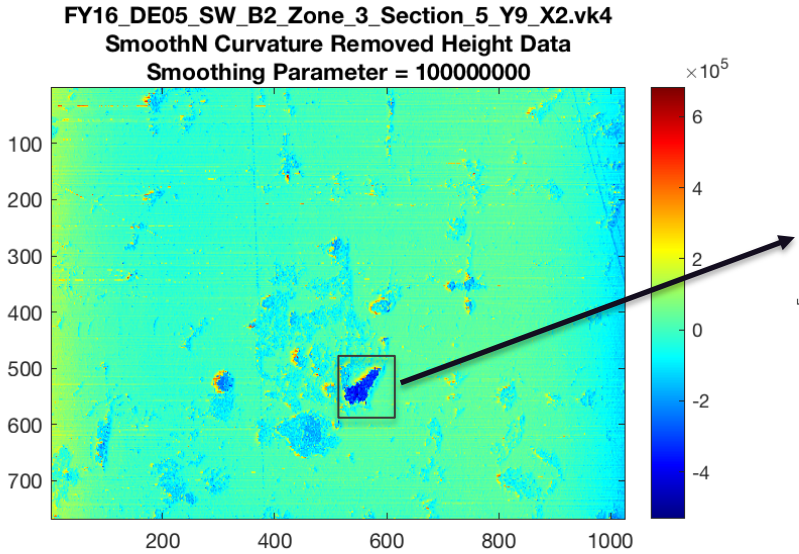


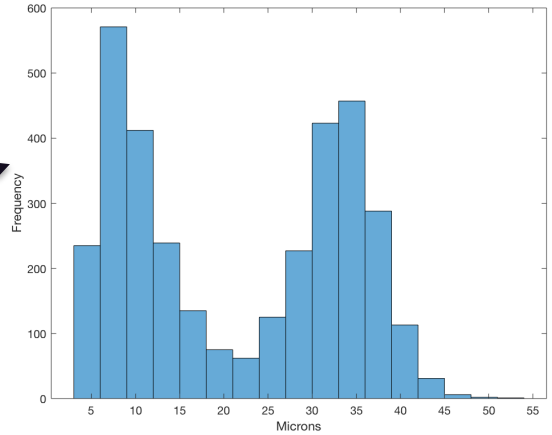
Num Pixels	Maximum Depth	Low Volume Microns Cubed	Centroid Row	Centroid Column
328	-46.03734	-54755.1614	360.405488	1412.14329



Individual vk4 file analysis of B2 Section 5 (Feature pixel depth analysis)

Num Pixels	Maximum Depth Microns	Low Volume Microns Cubed	Centroid Row	Centroid Column
3402	-52.776	-35719.7046	549.781893	524.137566





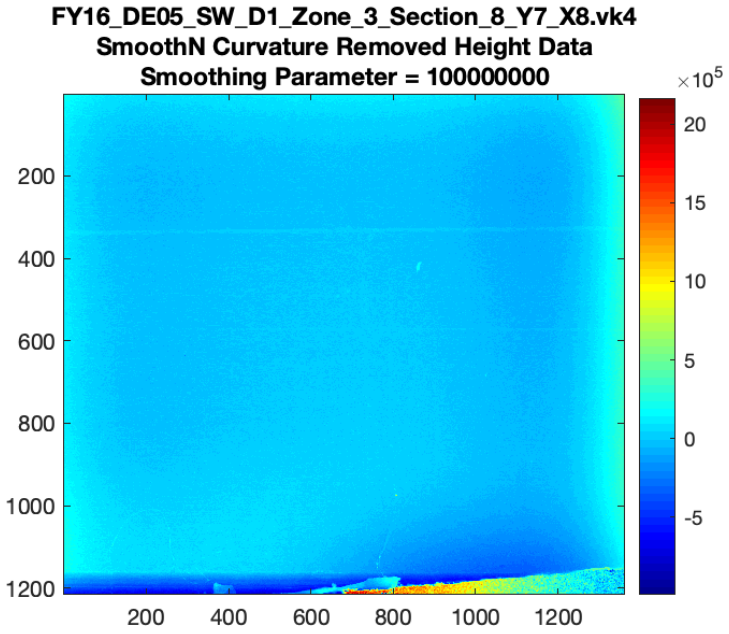
Distribution of the 3402 pixel depths for the highlighted feature of interest.

Ranking of the pixels for the feature of interest. There are 3402 pixels in the feature.

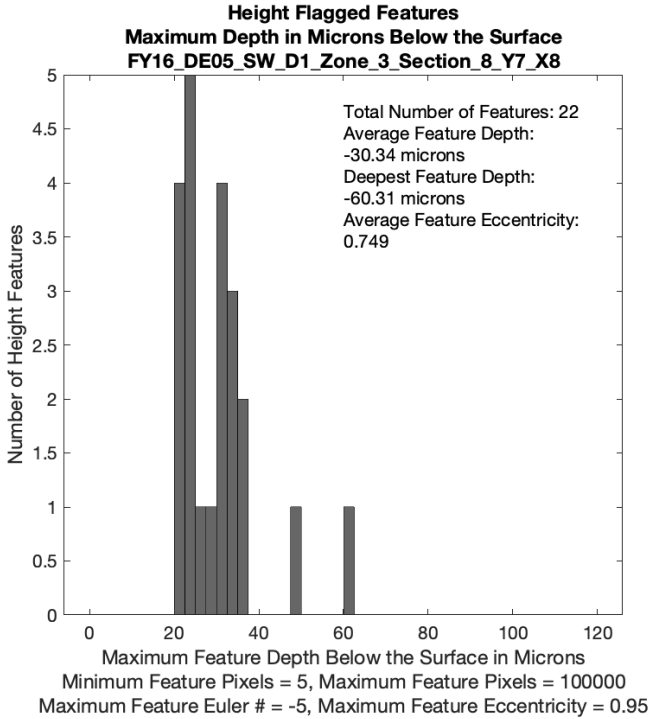
Pixel ranking	Micron Depth
1st	-52.776
5th	-46.649
10th	-44.852
20th	-43.621

Pit Depth Distribution: D1 Section 8
Volume Ranking 3; Deepest Pit Ranking: 2

Flattened Height Data

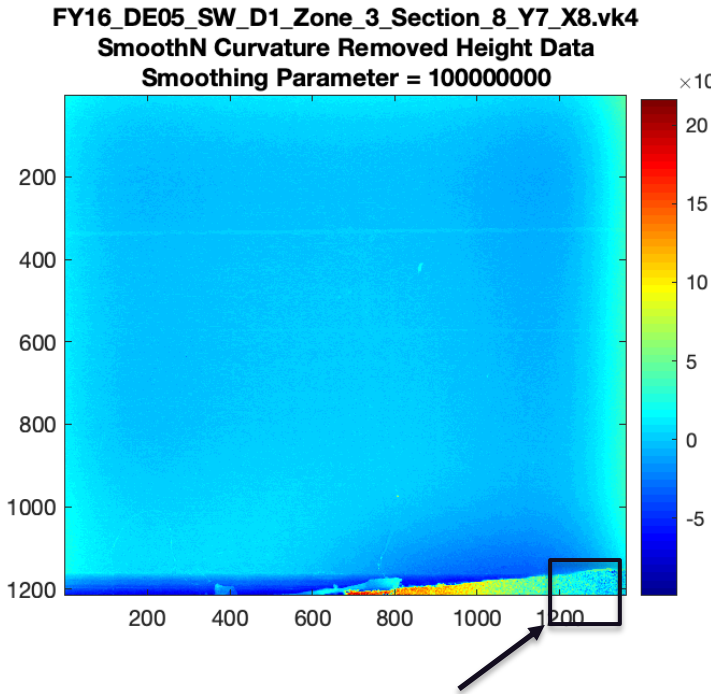


Flagged Height Features

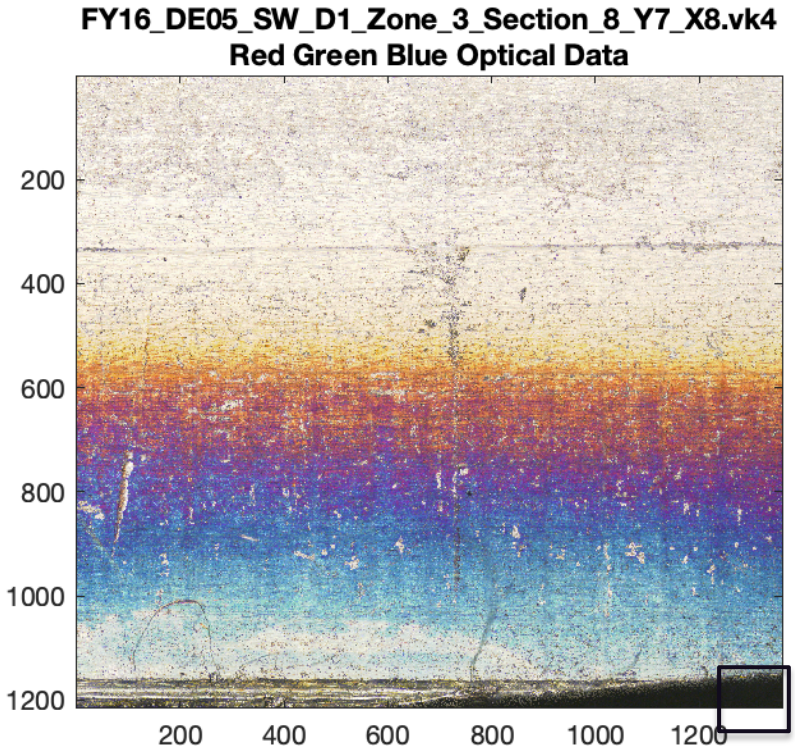


Pit Depth Distribution: D1 Section 8
Volume Ranking 3; Deepest Pit Ranking: 2

Flattened Height Data



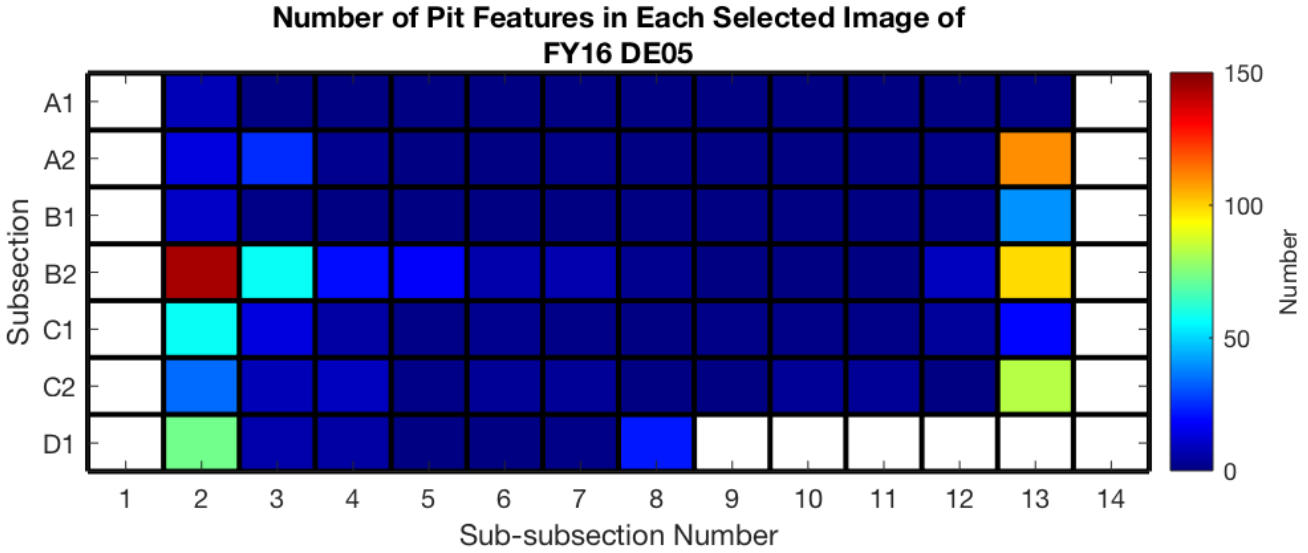
Feature identified in this location. Off-sample so not real.



Feature is off sample

Pit Feature Density YX Key: Height Data
FY16 DE05 Zone 3

Selected Images

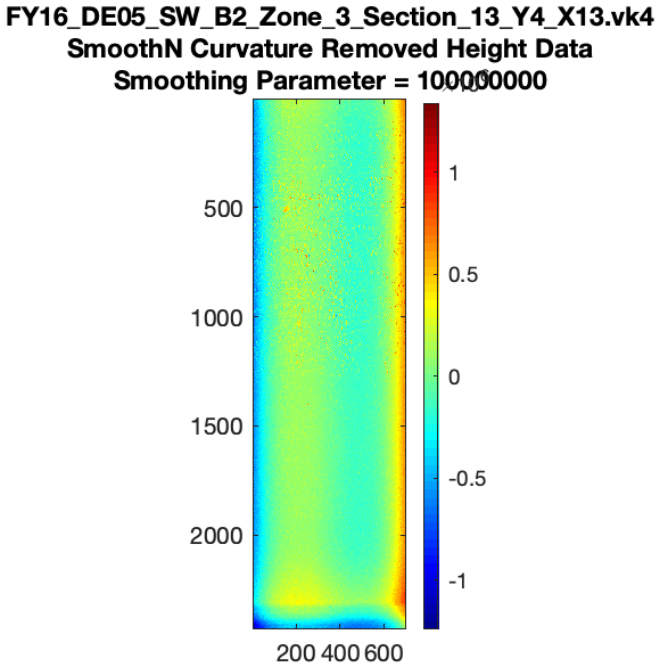


Increased numbers of features in sections 2 and 13 likely a result of larger curvature introducing noise.

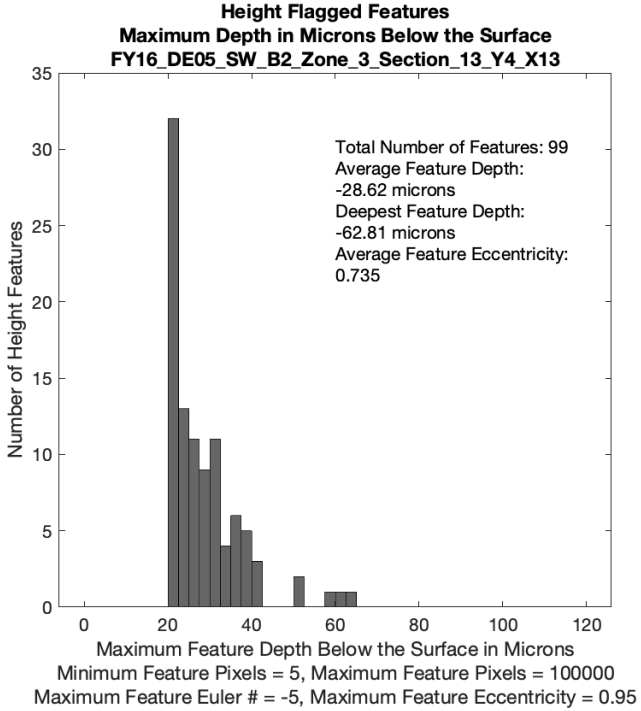
Additional Pit Analysis

Pit Depth Distribution: B2 section 13
Deepest Pit Ranking: 1

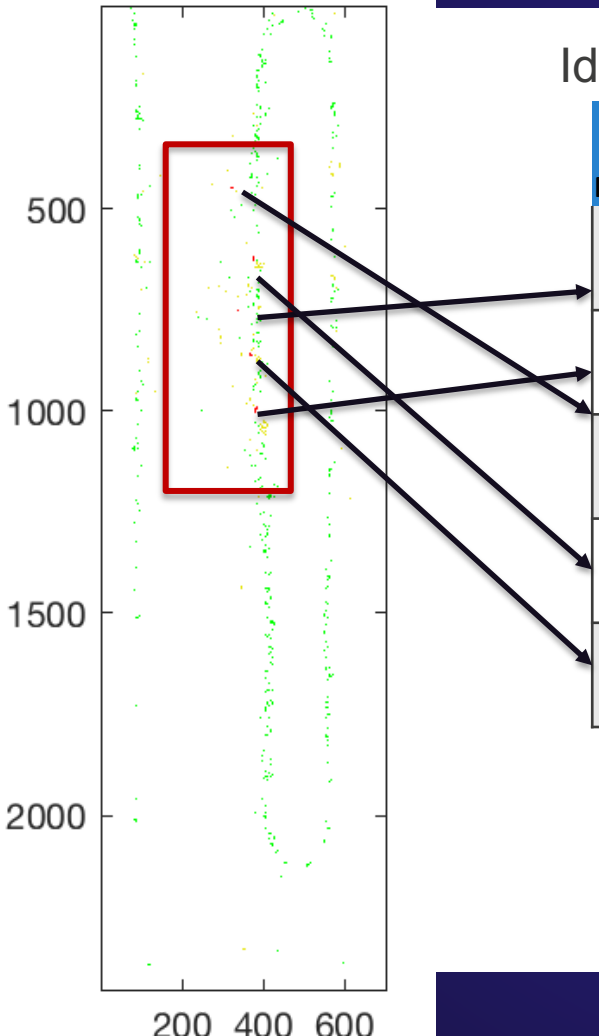
Flattened Height Data



Flagged Height Features



Flagged features for B2 Section 13



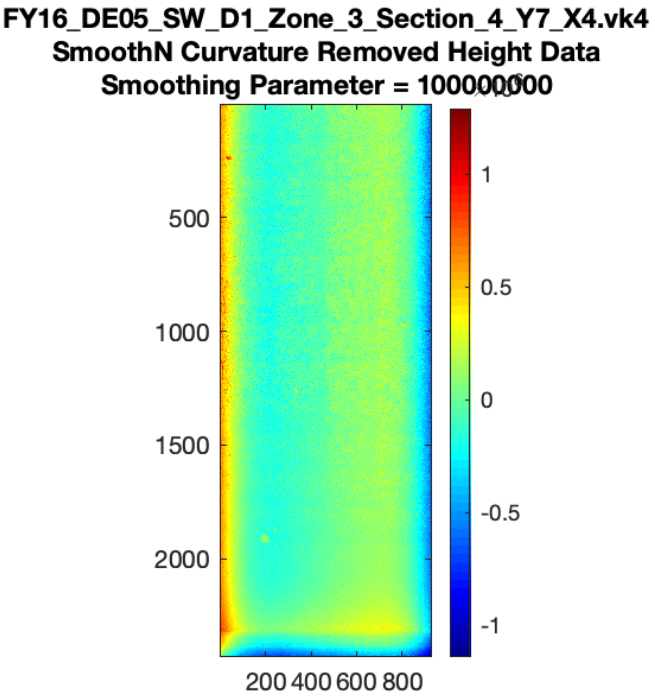
Identified flagged red (Depth >50 microns) features

NumPixels	MaximumDepthMicrons	LowVolumeMicronsCubed	CentroidRow	CentroidColumn
21	-62.813139	-4930.3246	336.761905	749.190476
87	-61.905546	-11964.306	381.287356	997.632184
19	-59.121989	-5165.4327	321.789474	447.631579
43	-51.172292	-6126.3313	375.697674	622.255814
27	-50.789693	-5111.578	368.62963	860.888889

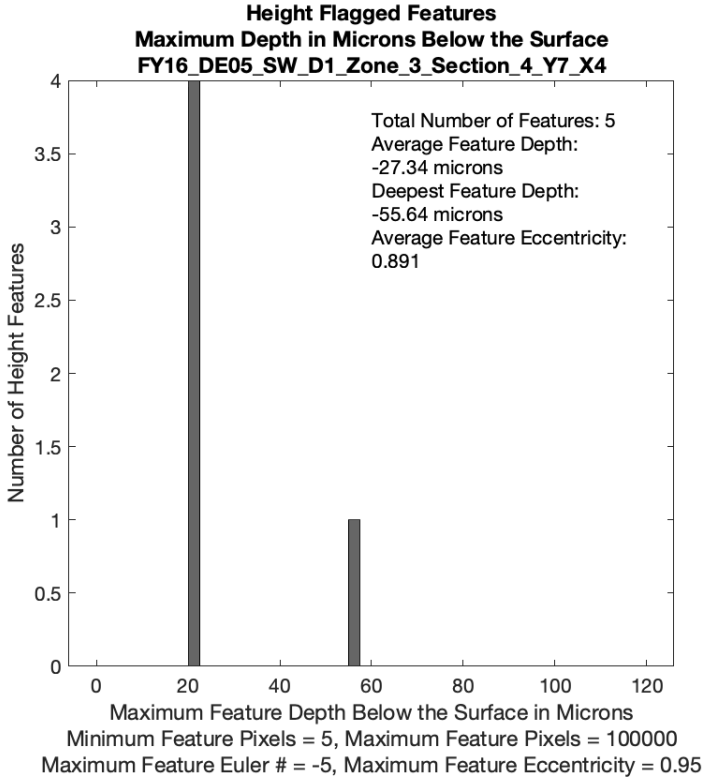
The number of pixels is low and the volume is not very large for each of the features.

Pit Depth D1 Section 4 Histogram Height Data
Deepest Pit Ranking: 4

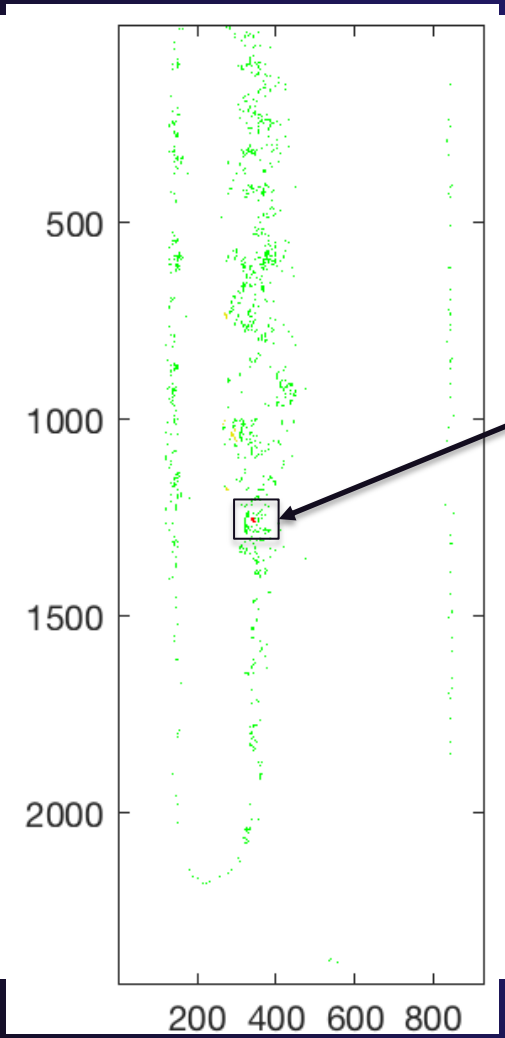
Flattened Height Data



Flagged Height Features



Pit Depth D1 Section 4 Histogram Height Data
Deepest Pit Ranking: 4



featuretype	FeatureNumber	Centroid_1	Centroid_2	NumPixels
Height	259	267.789474	1006.92982	57
Height	266	272.658228	736.341772	79
Height	274	275.522727	1176.52273	44
Height	292	293.136842	1040.06316	190
Height	567	341.709302	1255.74419	86

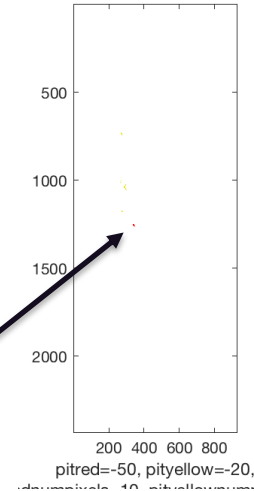
MaximumDepthMicrons	STDDepthMicrons	LowVolumeMicronsCubed
-20.125399	0.00234644	-5868.1348
-20.04865	0.0028289	-8694.3932
-20.594883	0.00273307	-4436.4949
-20.3075	0.00257737	-19855.309
-55.635307	0.01120239	-13936.377

There was only 1 flagged red feature and 4 yellow flagged features.

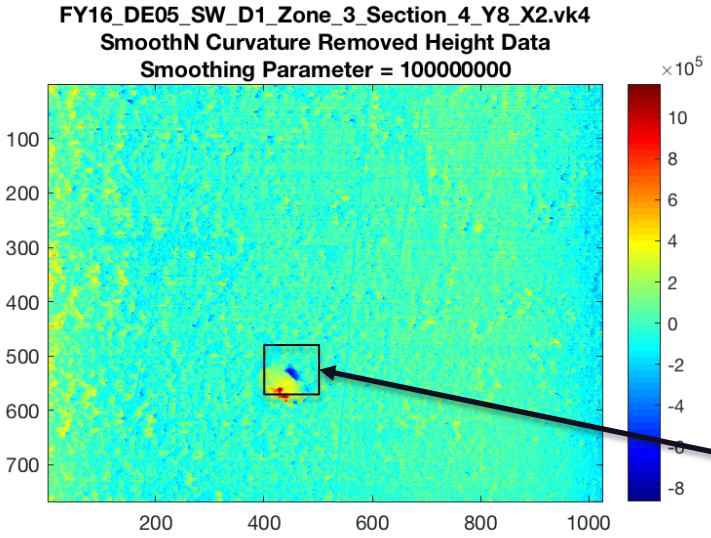
Individual image 20x image for D1 Section 4 Y8 X2

There are 60 individual 20x (15 rows and 4 columns) images that make up the montage of D1 Section 4.

Different depths likely a result of montage smoothing / 20X can be a single pixel or raised area near pit. Need to look at individual pixels.



20x height image for D1 Section 4, Y8 X2



Montage analysis results

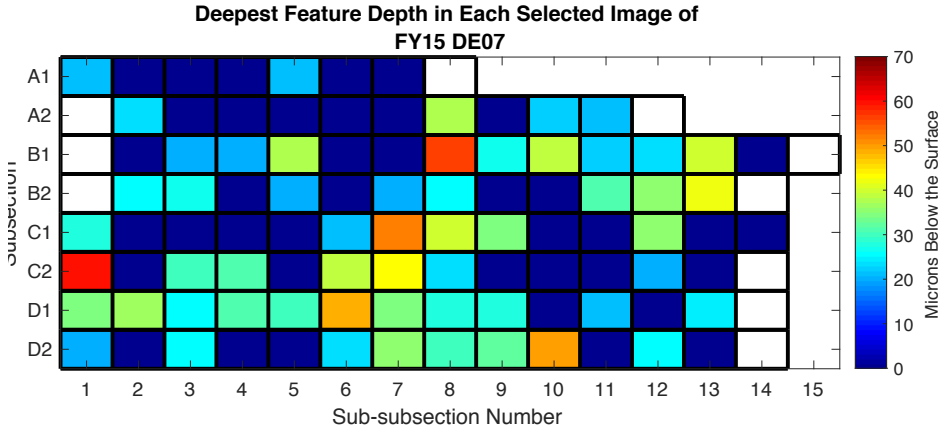
NumPixels	MaximumDepth	LowVolumeMicronsCubed	CentroidRow	CentroidColumn
86	-55.635	-13936.377	341.709302	1255.7442

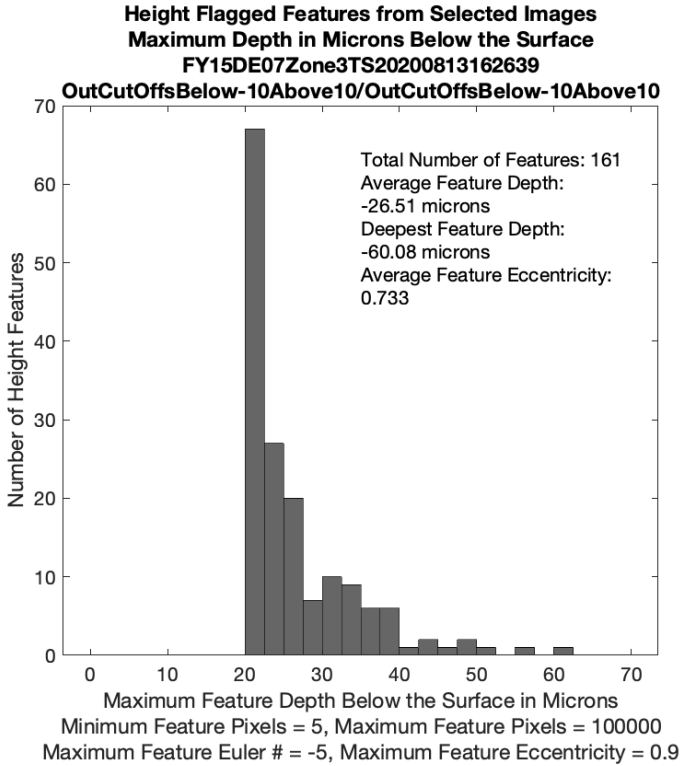
Individual 20X vk4 file analysis

NumPixels	MaximumDepthMicrons	LowVolumeMicronsCubed	CentroidRow	CentroidColumn
628	-86.1538	-10751.7965	455.699045	530.89172

Height Data Summary- FY15 DE07 Zone 3

First container, Michael was experimenting with sectioning

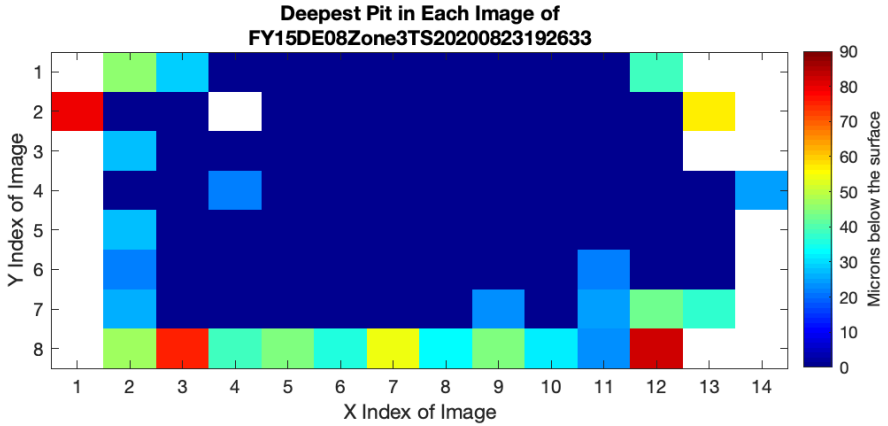


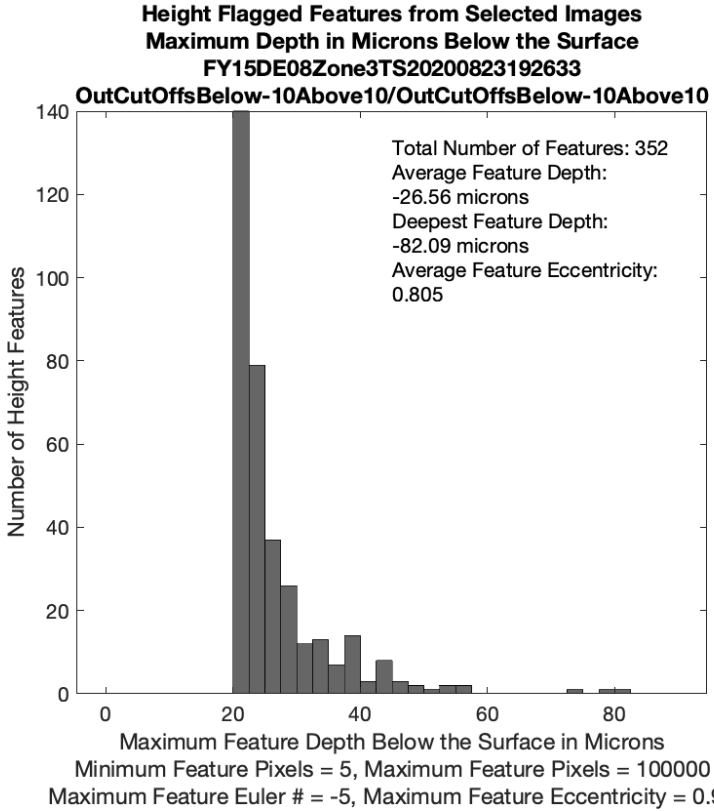


Note that deepest pit (-60.08) in histogram was in C2 Section 1. An edge piece that was not removed. Further analysis showed that this feature was in the off sample portion, so not valid. The actual deepest pit was in B1 Section 8 (-56.7 microns).

Height Data Summary- FY15 DE08 Zone 3

Just discovered that there is a problem with data from A2, so it is not correct. But based on the remainder of the data it appears that this container has deeper pits than the previous two. Michael reported that this lid had more agglomerated pits than the other containers.





The deepest pit (-82.09) in histogram was in D2 Section 12 (Y8 X12 on montage).

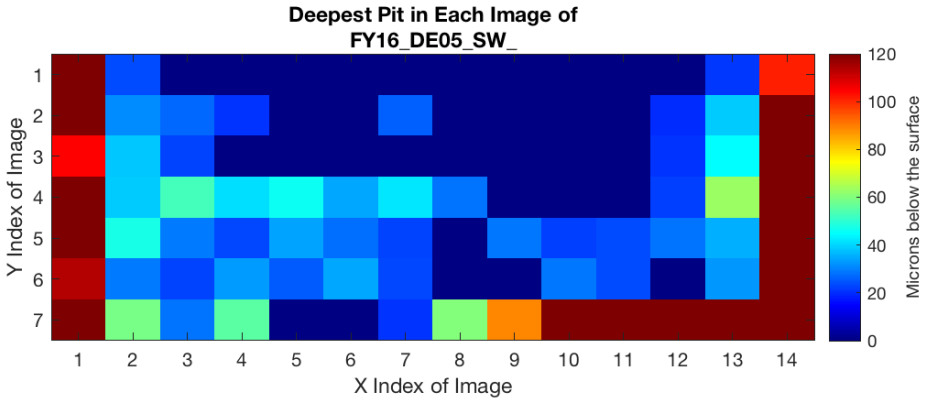
Summary

- Montage analysis provides depth and volume of pits for ranking for further investigation by SME
  - Montage max pit depths are generally 10 to 20 microns less than 20X images (montage does more smoothing than 20X)
  - Based on Keyence and Gwyddion analysis, montage depth is a reasonable measure of depth
  - A robust estimator for 20X depth could remove single pixel issues (i.e., use 5th deepest or 10th deepest)
- Based on the montage analysis of first two complete ICCWR DEs, there are no pits deeper than 63 microns in Zone 3. The third container has deeper pits, at least one that is 82 microns deep.
  - Based on pit growth modeling these pit depths support position that a through-wall pit is extremely unlikely over 50 year storage period.
- WAMS resolution comparable to montage (approximately 3.6 micron per side per pixel)
  - WAMS height data likely to be adequate for pit depth / size analysis
- Should we still look at pit depths during surveillance?
  - LANL CWG consensus is that, although we believe that through-wall pitting is not an potential problem for 3013 containers, we don’t know enough to stop evaluating pit depths at this time.

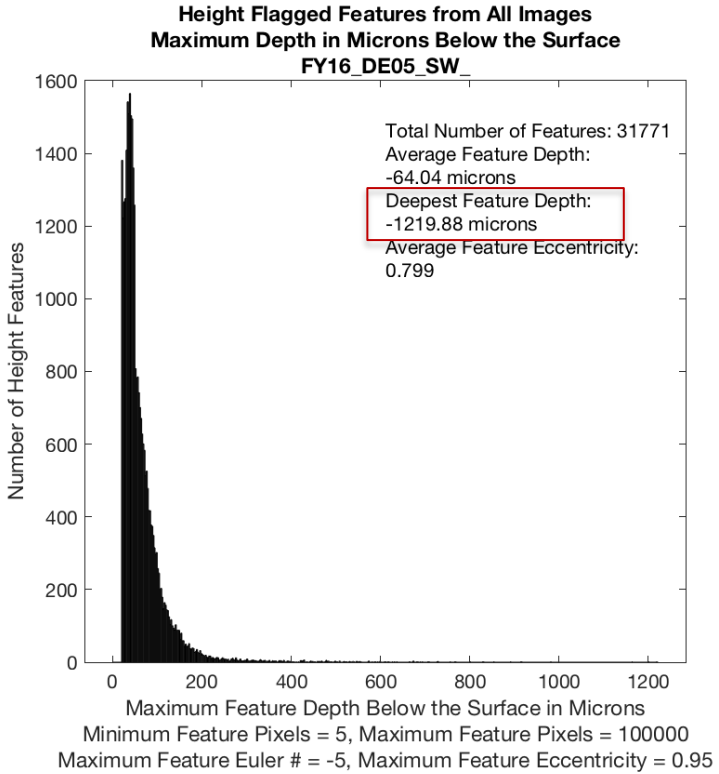
Backup Slides

Height Data Histogram that includes off-sample regions

The depths are artifacts of the edge of the microscope

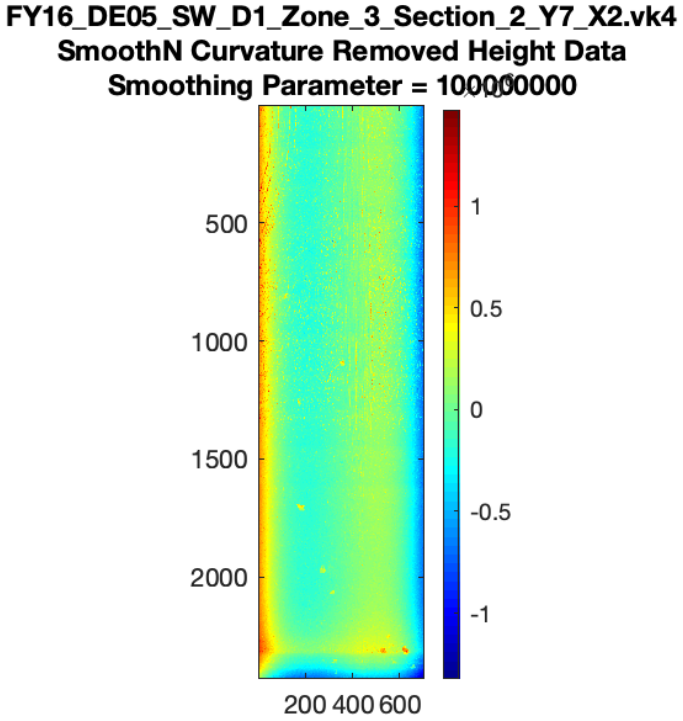


- **Pit Depth Histogram - All Images**

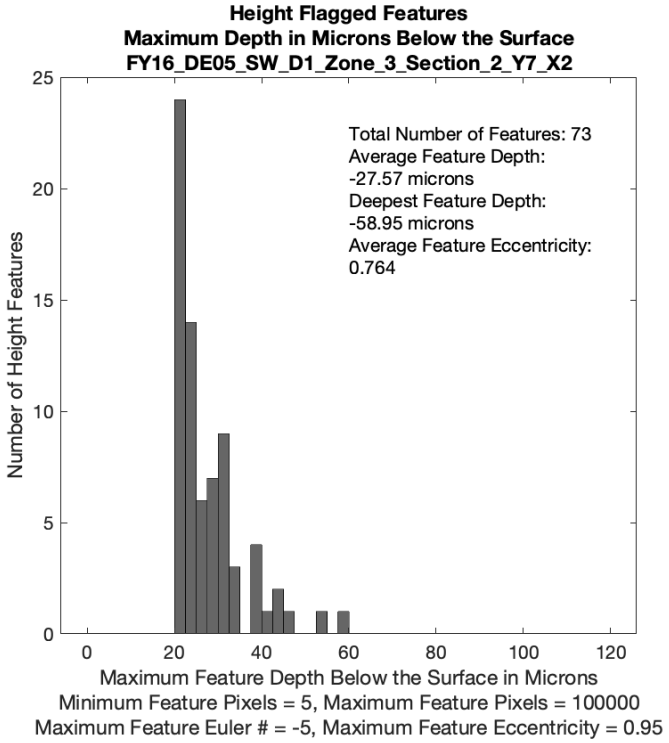


Pit Depth Distribution: D1 Section 2
Deepest Pit Ranking: 3

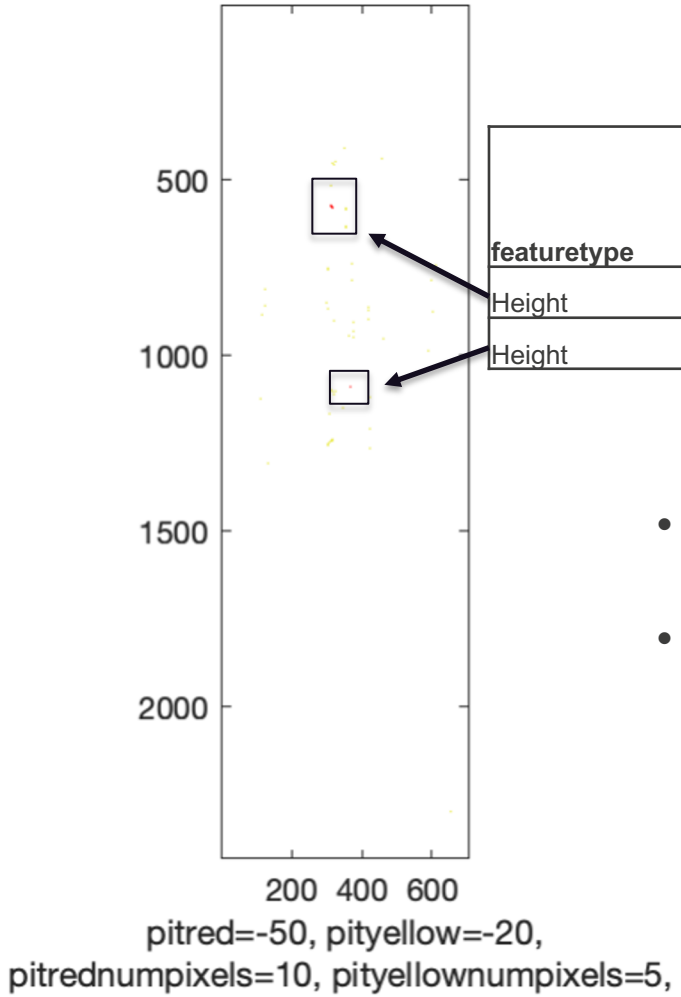
Flattened Height Data



Flagged Height Features



D1 Section 2 Flagged features

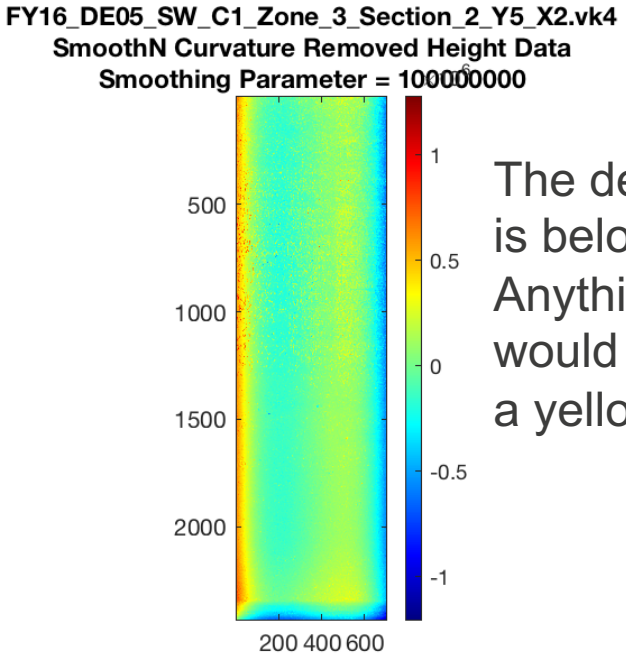


featuretype	Centroid_1	Centroid_2	NumPixels	MaximumDepthMicrons	LowVolumeMicronsCubed
Height	314.089744	577.5	78	-58.948815	-11094.178
Height	365.733333	1086.66667	15	-52.638364	-3548.211

- The largest feature has a depth of -59 microns.
- All the features are found in the middle of the image.

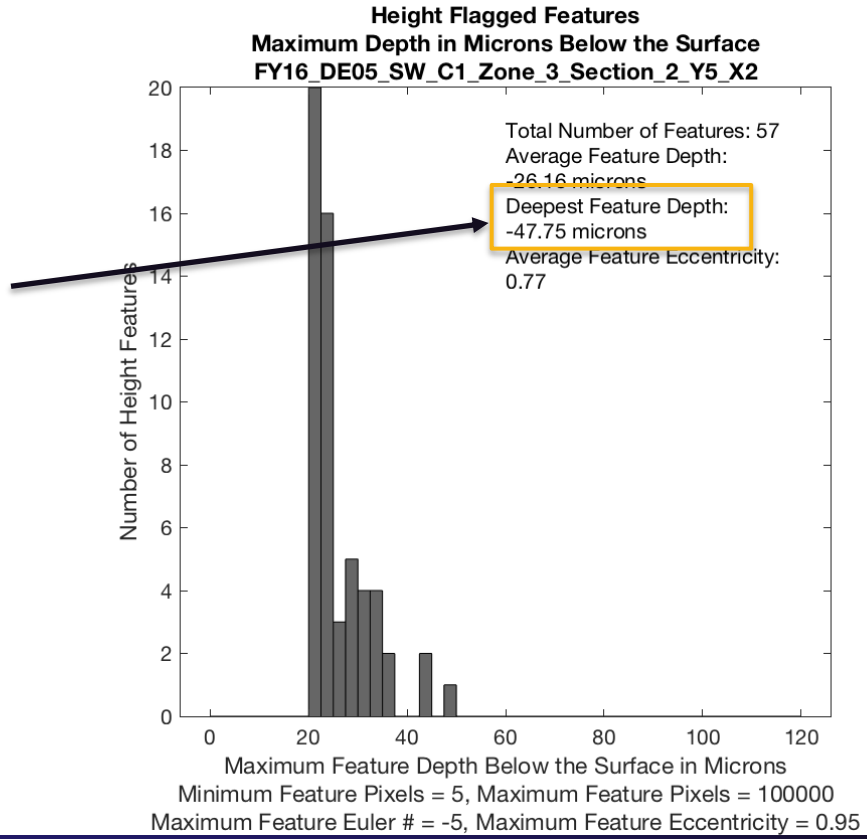
Pit Depth C1 Section 2 Histogram Height Data
Deepest Pit Ranking: 6

Flattened Height Data



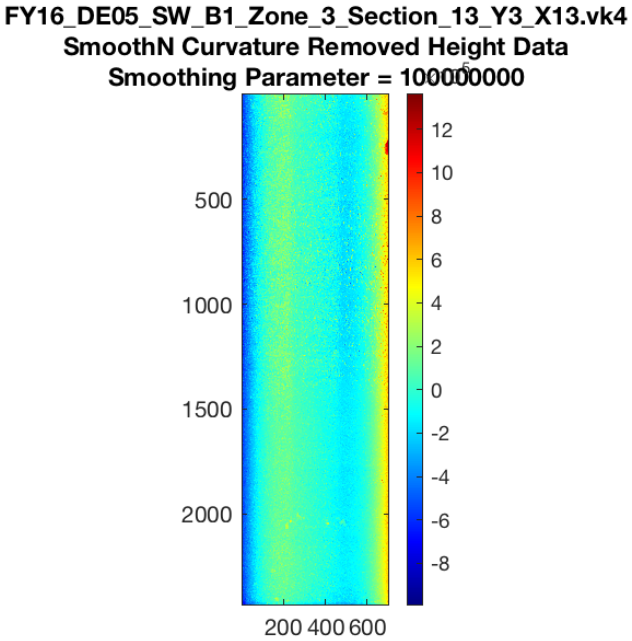
The deepest feature is below 50 microns. Anything below 50 would be flagged as a yellow feature.

Flagged Height Features

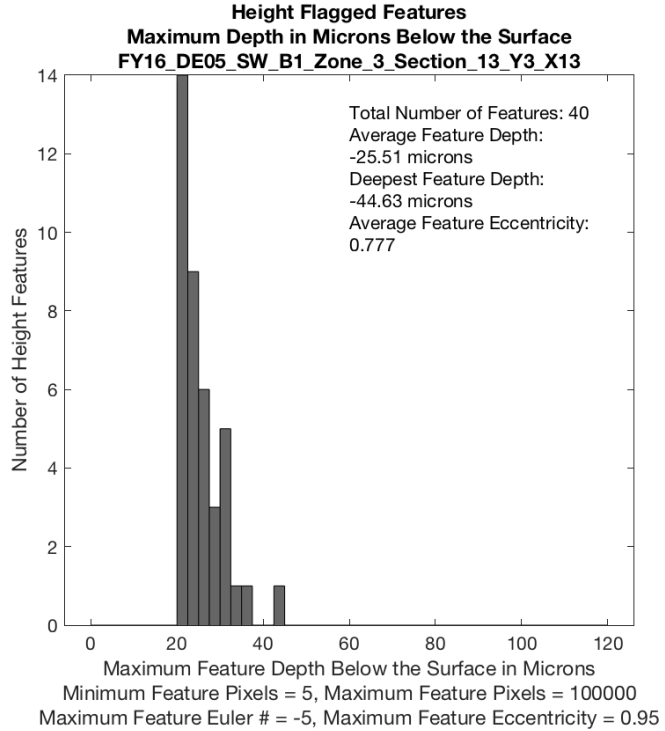


Pit Depth B1 Section 13 Histogram Height Data
Deepest Pit Ranking: 8

Flattened Height Data

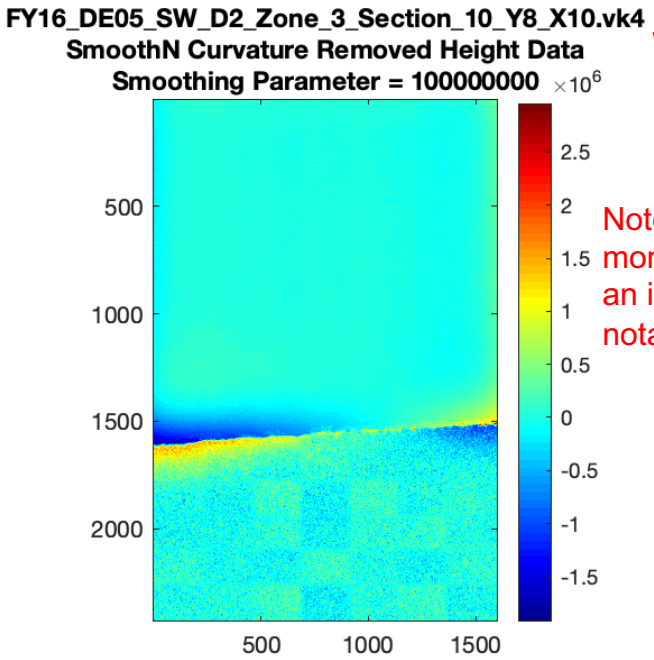


Flagged Height Features



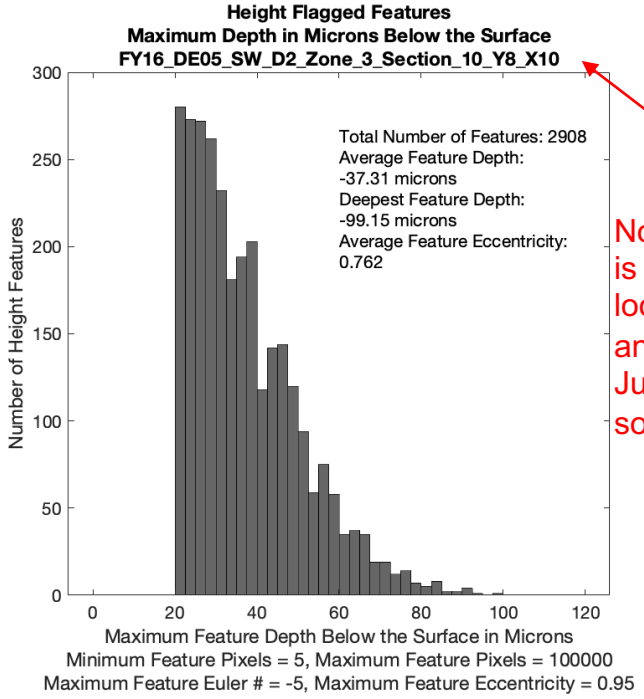
Montage with Deepest Pit (Ranking:1) D2 Section 10 (Piece with an edge or weld region)

Flattened Height Data



Note that Y8_X10 is a montage location not an image location. Just notation for software.

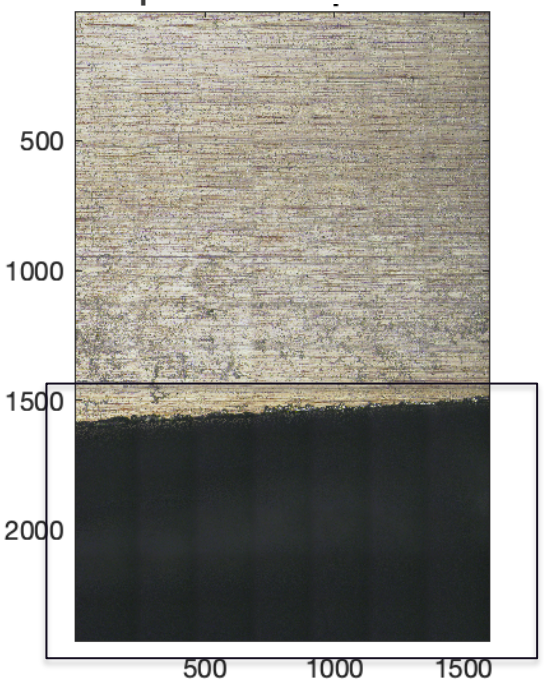
Flagged Height Features



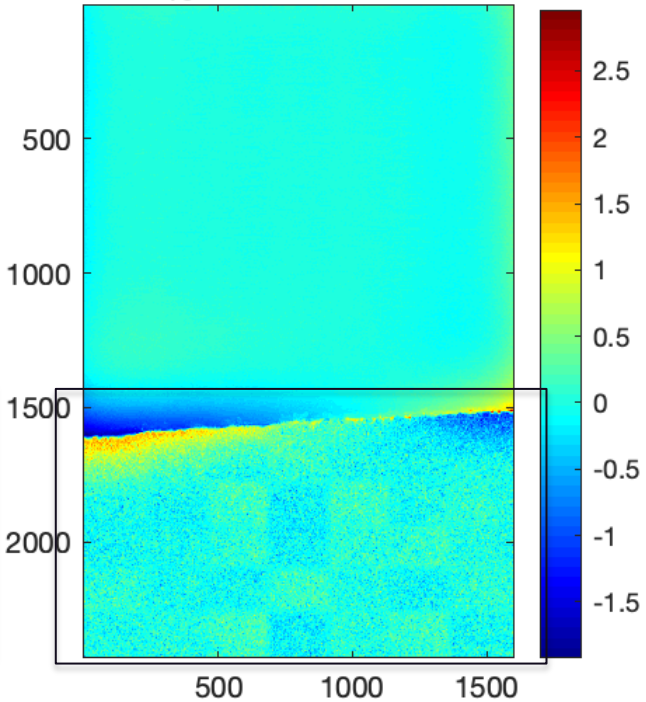
Note that Y8_X10 is a montage location not an image location. Just notation for software.

D2 Section 10 flagged features

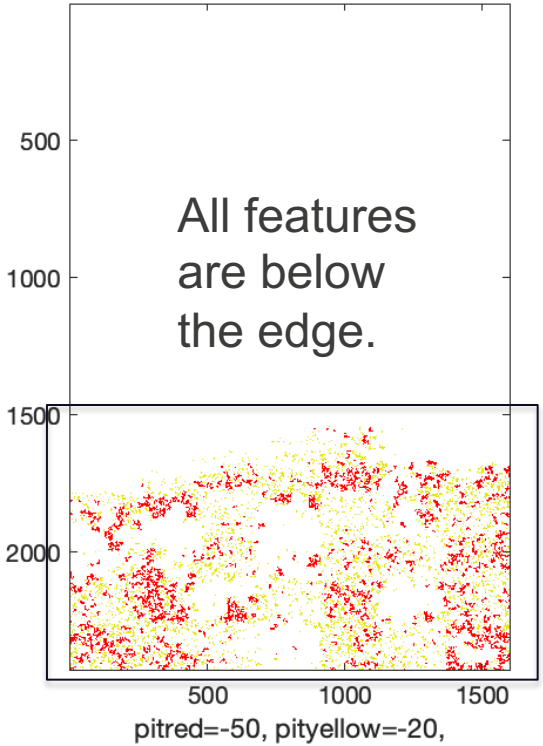
Optical



Height



Flagged features



pitred=-50, pityellow=-20,