

Capturing interpretational uncertainty of depositional environments with Artificial Intelligence

Thesis Appendix

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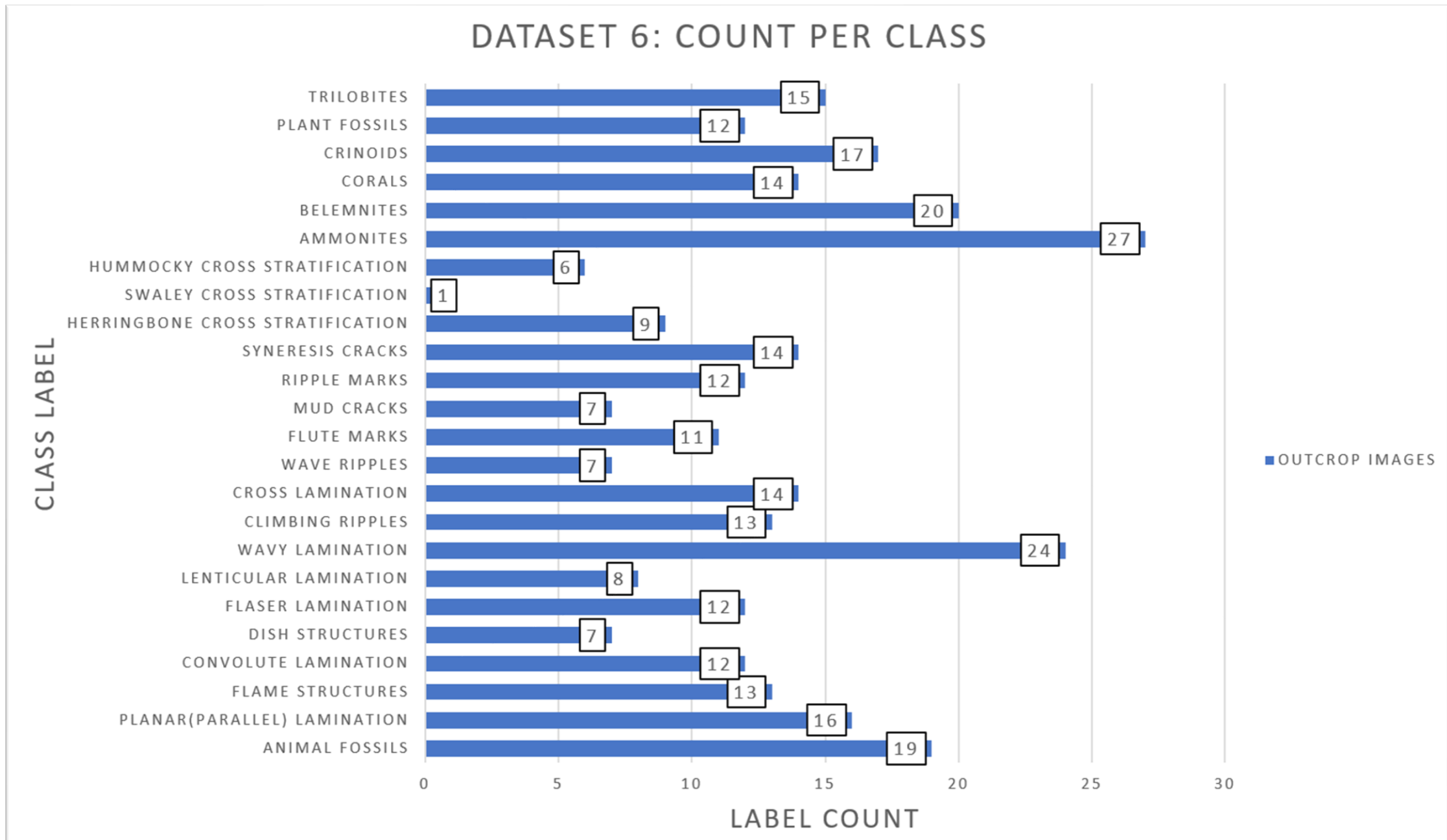


Figure 4-12: Dataset 6 Class labels vs. the label count. The figure shows the number of occurrences of each class in the dataset.

Dataset 7 (Blended Dataset: Outcrop Images + Sketches)					Outcrop Images			Sketches		
Classes	Number of Images	Train	Validation	Test	Train	Validation	Test	Train	Validation	Test
Animal Fossils	35	26	6	3	18	4	3	8	2	0
Planar(Parallel) Lamination	34	24	6	4	15	4	4	9	2	0
Flame Structures	29	21	6	2	12	4	2	9	2	0
Convolute Lamination	24	17	5	2	9	3	2	8	2	0
Dish Structures	20	13	5	2	6	3	2	7	2	0
Flaser Lamination	30	22	6	2	11	3	2	11	3	0
Lenticular Lamination	23	17	4	2	10	2	2	7	2	0
Wavy Lamination	37	23	9	5	12	6	5	11	3	0
Climbing Ripples	26	19	5	2	12	3	2	7	2	0
Cross Lamination	32	23	6	3	13	3	3	10	3	0
Wave Ripples	16	11	3	2	6	2	2	5	1	0
Flute Marks	28	19	6	3	11	3	3	8	3	0
Mud Cracks	19	14	4	1	8	2	1	6	2	0
Ripple Marks	31	23	6	2	12	3	2	11	3	0
Syneresis Cracks	27	20	5	2	12	3	2	8	2	0
Herringbone Cross Stratification	20	15	3	2	9	3	2	6	0	0
Swaley Cross Stratification	2	1	0	1	1	0	1	0	0	0
Hummocky Cross Stratification	17	12	4	1	3	2	1	9	2	0
Ammonites	49	33	12	4	23	9	4	10	3	0
Belemnites	36	27	7	2	19	4	2	8	3	0
Corals	27	20	5	2	15	3	2	5	2	0
Crinoids	32	23	6	3	16	4	3	7	2	0
Plant Fossils	25	17	6	2	11	4	2	6	2	0
Trilobites	33	25	6	2	15	4	2	10	2	0
Total number of images	652	465	131	56	279	81	56	186	50	0
Data Split, %	100	71	20	9	60.0	61.8	100.0	40.0	38.2	0.0

- Classes Labels
- Number of Images per Class
- Overall Image Split
- Outcrop Proportions
- Sketch Proportions

Table 4-11: Detailed breakdown of Dataset 7.

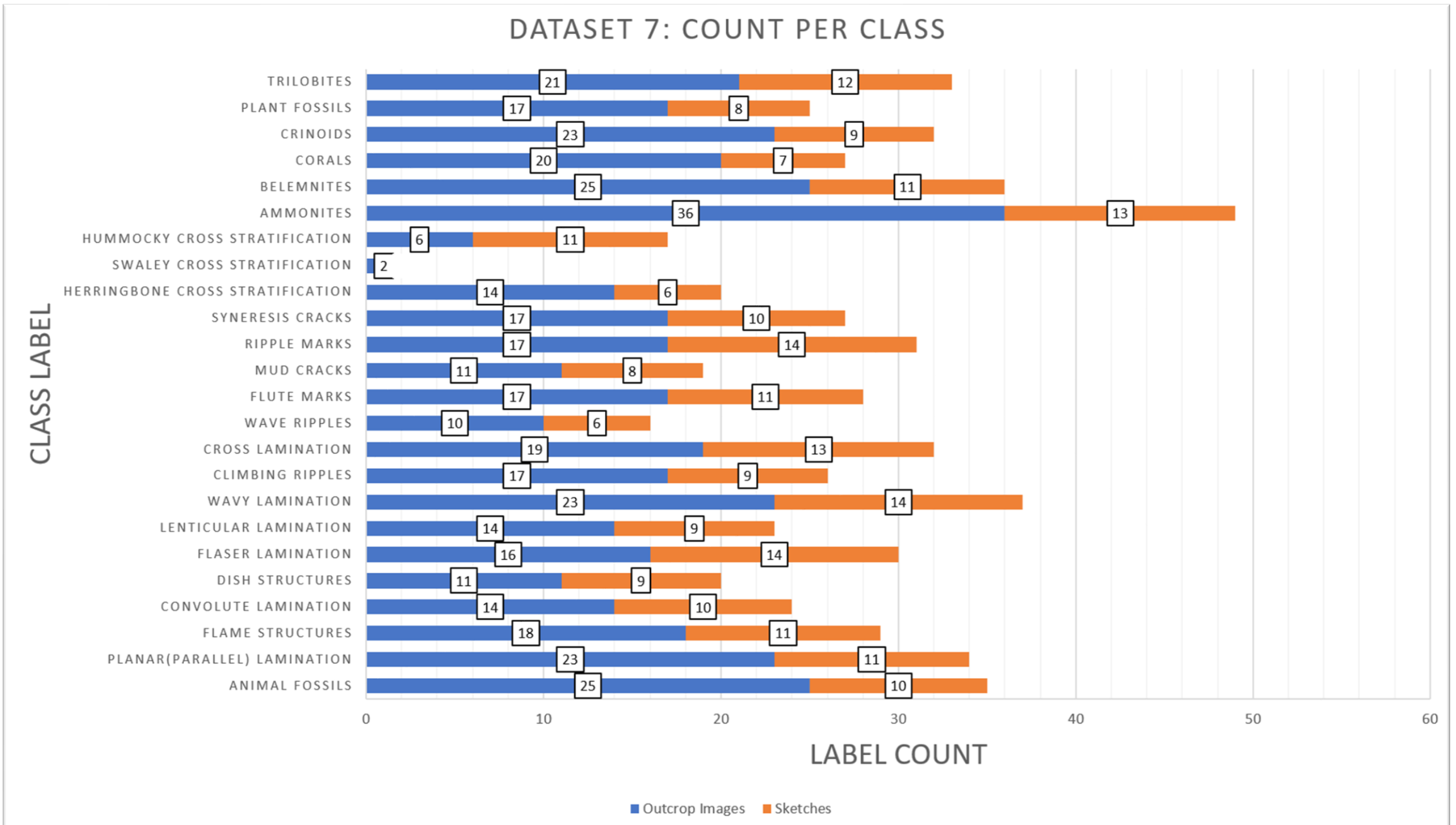


Figure 4-13: Dataset 7 Class labels vs. the label count. The figure shows the number of occurrences of each class in the dataset.

Dataset 8			
Object Detection YOLOv6 Labels for Sedimentary Structures	Label Count in Training and Validation set	Label Count in Training set	Label Count in Validation set
Bioturbation	25	18	8
Clasts	32	22	10
Convolute/Irregular Bedding	2	1	1
Cross Bedding/Stratification	25	18	8
Cross Lamination/Climbing Ripples	13	9	4
Desiccation Cracks	5	4	2
Erosive Features	24	17	7
Fault	7	5	2
Flame Structures	3	2	1
Flaser Lamination	2	1	1
Fossils	4	3	1
Herringbone Cross Stratification	7	5	2
Hummocky Cross Stratification	6	4	2
Lenses	13	9	4
Lenticular Bedding	5	4	2
Lenticular Lamination	4	3	1
Planar/Parallel Bedding	26	18	8
Planar/Parallel Lamination	15	11	5
Structureless	24	17	7
Swaley Cross Stratification	2	1	1
Syneresis Cracks	2	1	1
Wave Ripples/Lamination	5	4	2
Wavy Bedding	2	1	1
Total Number of Labels	253	177	76
Percentage of labels, %	100	70	30

- Classes
- Number of Labels
- Label Split
- Image Split

Dataset 8 (Outcrop Images)		
Total Number of Images	138	100%
Training set Images	97	70%
Validation set Images	41	30%

Table 4-12: Detailed breakdown of Dataset 8.

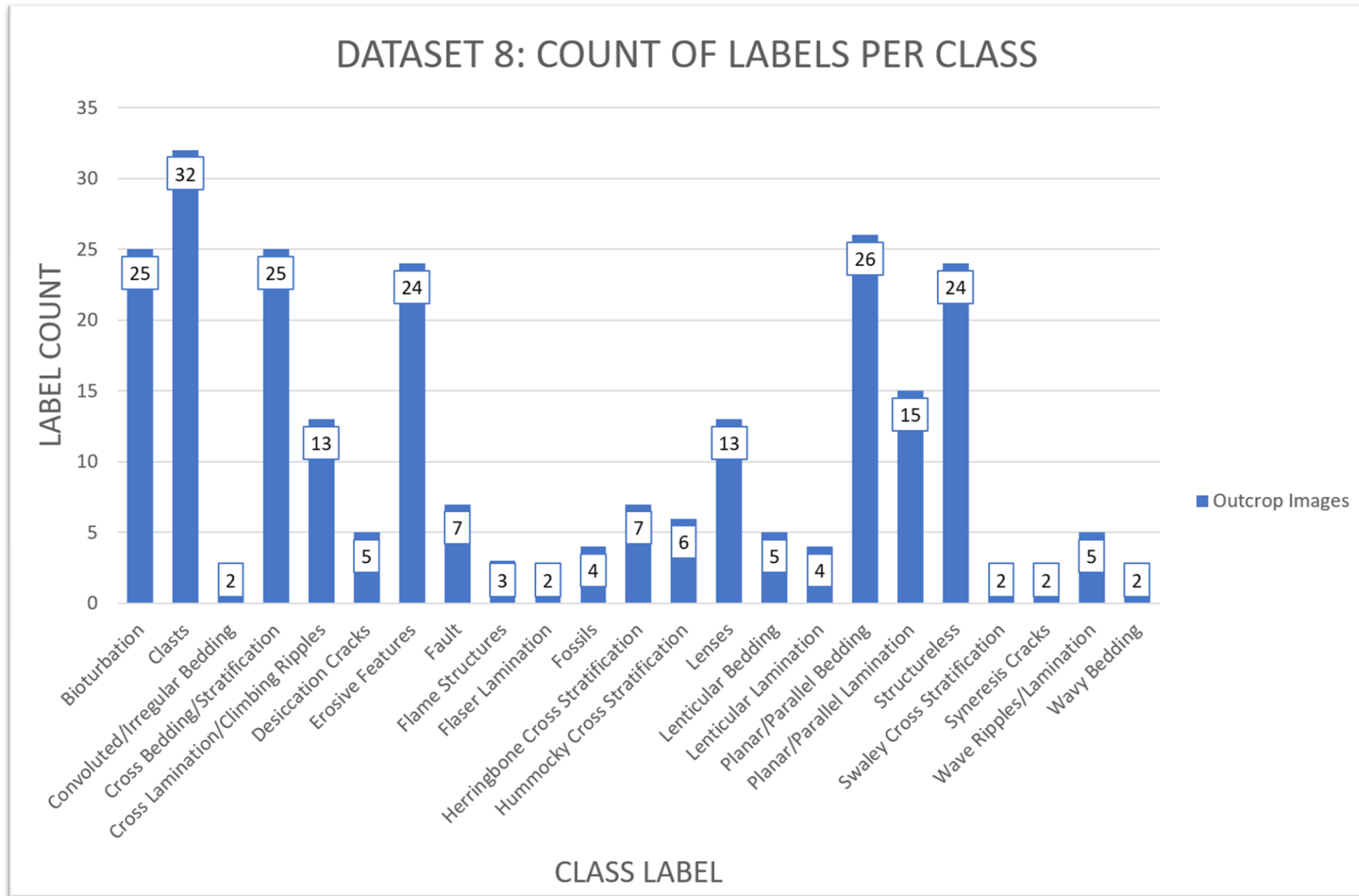


Figure 4-14: Count of labels per class for Dataset 8.

Dataset 10B (Outcrop Images)			
Instance Segmentation Yolact Labels for Sedimentary Structures	Label Count in Training and Validation set	Label Count in Training set	Label Count in Validation set
Bioturbation	48	34	14
Clasts	52	36	16
Convolutd/Irregular Lamination	2	1	1
Convolutd/Irregular Bedding	2	1	1
Cross Bedding/Stratification	39	27	12
Cross Lamination/Climbing Ripples	22	15	7
Dessication Cracks	6	4	2
Erosive Contacts/Bases	76	53	23
Erosive Features	31	22	9
Faults	16	11	5
Flame Structures	6	4	2
Flaser Lamination	3	2	1
Flute Marks	42	29	13
Fossils	12	8	4
Herringbone Cross Stratification	9	6	3
Hummocky Cross Stratification	10	7	3
Lenticular Bedding	8	6	2
Lenticular Lamination	6	4	2
Planar/Parallel Bedding	46	32	14
Planar/Parallel Lamination	29	20	9
Scour Marks	6	4	2
Structureless	56	39	17
Swaley Cross Stratification	4	3	1
Syneresis Cracks	2	1	1
Wave Ripples/Lamination	6	4	2
Wavy Bedding	6	4	2
Total Number	545	382	164
Percentage of labels	100	70	30

- Classes
- Number of Labels
- Label Split
- Image Split

Dataset 10B (Outcrop Images)		
Total Number of Images	70	100%
Training set Images	49	70%
Validation set Images	21	30%

Table 4-16: Detailed breakdown of dataset 10B.

DATASET 10B: COUNT OF SEDIMENTARY STRUCTURES LABELS PER CLASS

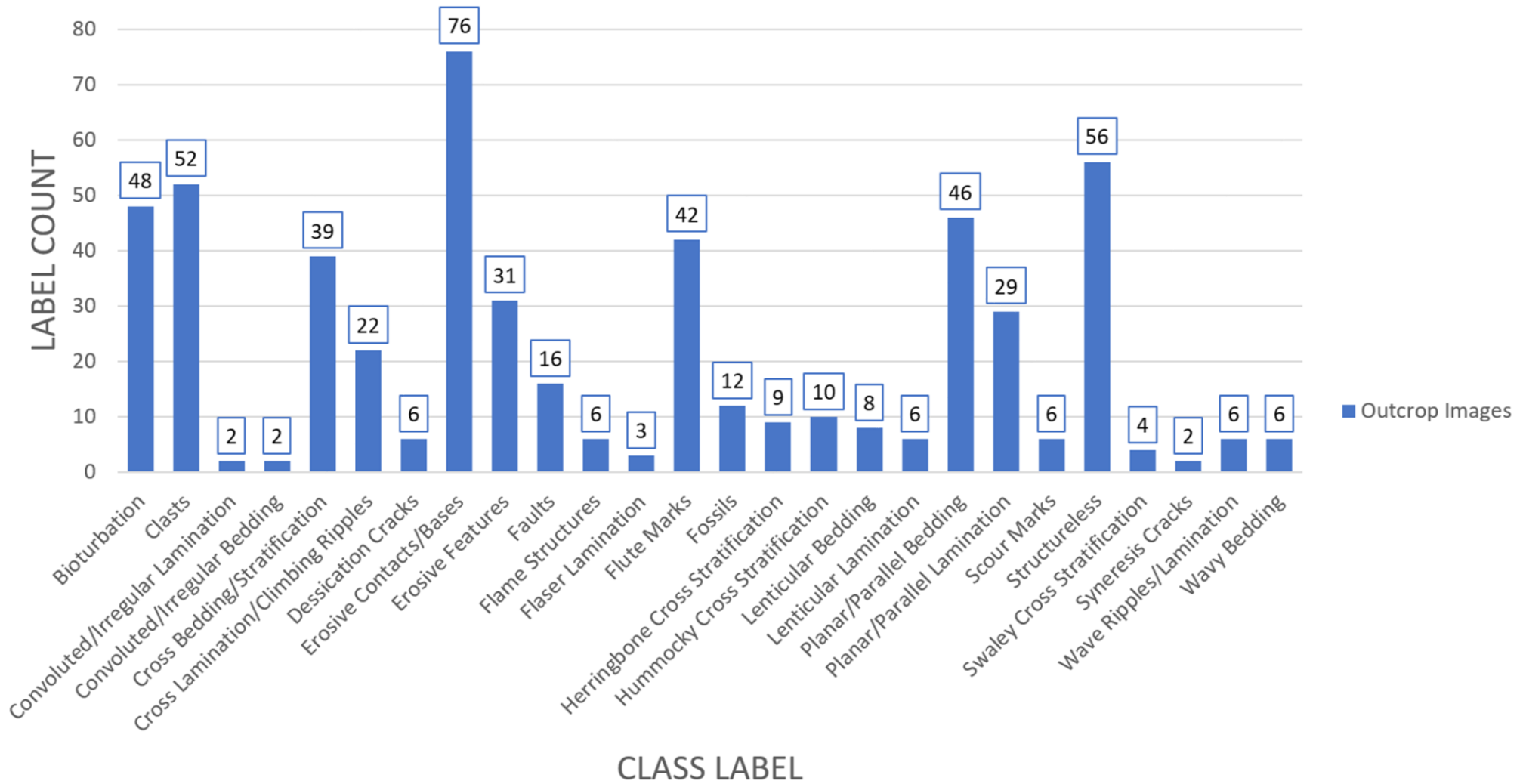
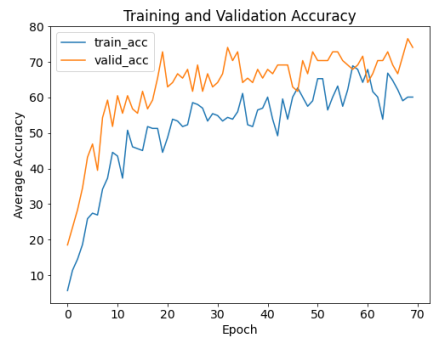
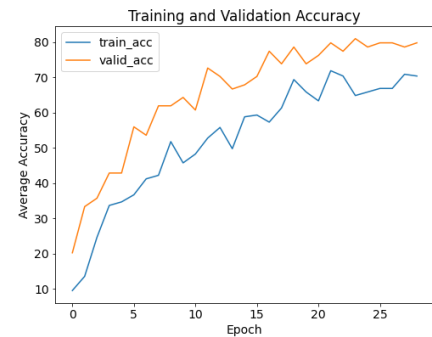
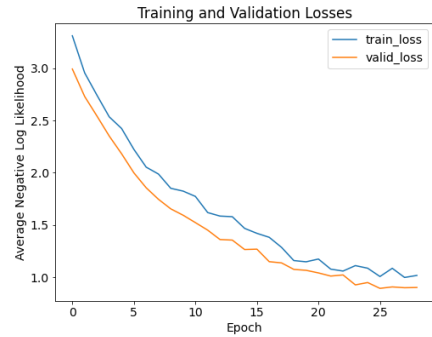


Figure 4-18: Count of labels per class for dataset 10B.

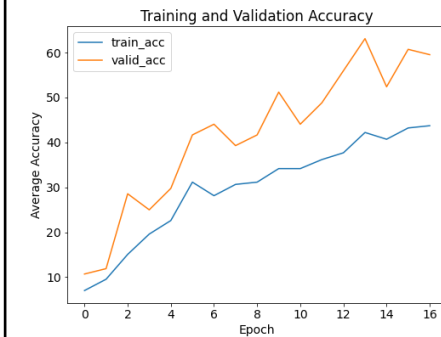
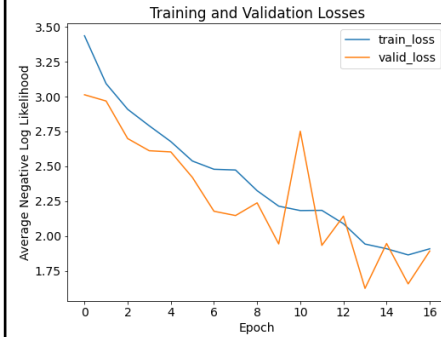
ResNet18



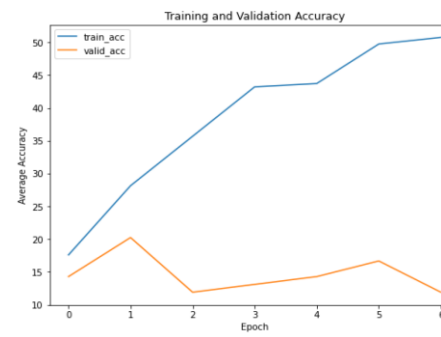
ResNet50



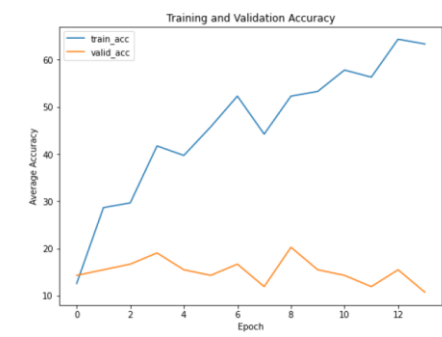
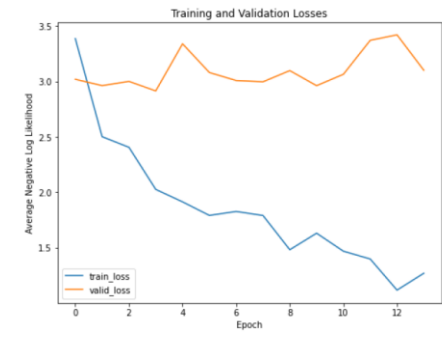
ResNet101



VGG16



VGG19



Loss

Accuracy

Figure 5-14: Loss and Accuracy versus the number of epochs for each model.

ResNet18



ResNet50



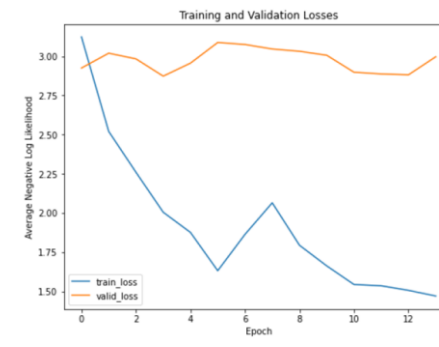
ResNet101



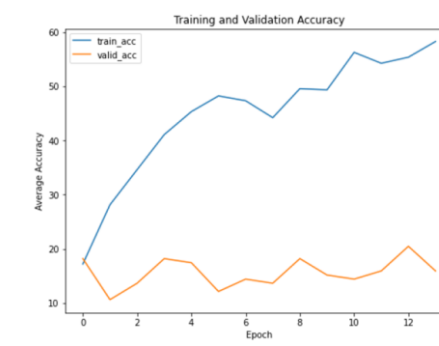
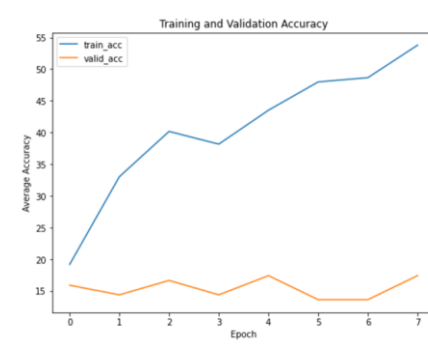
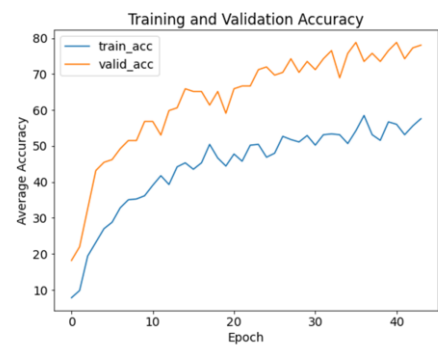
VGG16



VGG19



Loss



Accuracy

Figure 5-24: Accuracy and Loss versus the number of epochs for each model.

Object Detection Yolov6 for Sedimentary Structures on Outcrop Data				
Labels/Classes	Label Count in Training and Validation Sets	Predicted Label Appearances in test data	Misclassifications per Label (Class)	Percentage of misclassifications per class, %
Bioturbation	25	59	0	0
Clasts	32	47	7	15
Convolute/Irregular Bedding	2	4	0	0
Cross Bedding/Stratification	25	41	14	34
Cross Lamination/Climbing Ripples	13	14	3	21
Desiccation Cracks	5	6	0	0
Erosive Features	24	17	1	6
Fault	7	9	0	0
Flame Structures	3	2	0	0
Flaser Lamination	2	0	0	0
Fossils	4	27	1	4
Herringbone Cross Stratification	7	15	11	73
Hummocky Cross Stratification	6	4	1	25
Lenses	13	12	0	0
Lenticular Bedding	5	6	0	0
Lenticular Lamination	4	3	0	0
Planar/Parallel Bedding	26	39	1	3
Planar/Parallel Lamination	15	25	4	16
Structureless	24	34	1	3
Swaley Cross Stratification	2	2	1	50
Syneresis Cracks	2	2	1	50
Wave Ripples/Lamination	5	7	0	0
Wavy Bedding	2	5	0	0
Total	253	380	46	
Total Percentage of misclassifications for Test set, %				12

Table 6-5: Quantitative Results of YOLOv6-S on Outcrop Images (Dataset 8).

Object Detection Yolov6 for Fossils				
Labels/Classes	Label Count in Training and Validation Sets	Predicted Label Appearances in test data	Misclassifications per Label (Class)	Percentage of misclassifications per class, %
Ammonite	52	40	2	5
Animal Fossil	17	11	4	36
Belemnite	43	31	0	0
Coral	25	11	2	18
Crinoid	63	7	2	29
Plant Fossil	27	12	0	0
Trilobite	21	11	0	0
Total	248	123	10	
Total Percentage of misclassifications for Test set, %				8

Table 6-9: Quantitative Results of YOLOv6-S on Fossil Images (Dataset 11).

Object Detection Yolov6 for Sedimentary Structures on Core Data				
Labels/Classes	Label Count in Training and Validation Sets	Predicted Label Appearances in test data	Misclassifications per Label (Class)	Percentage of misclassifications per class, %
Bioturbation	25	5	5	100
Clasts	32	20	0	0
Convoluted/Irregular Bedding	2	0	0	0
Cross Bedding/Stratification	25	57	14	25
Cross Lamination/Climbing Ripples	13	6	0	0
Desiccation Cracks	5	0	0	0
Erosive Features	24	28	1	4
Fault	7	0	0	0
Flame Structures	3	0	0	0
Flaser Lamination	2	0	0	0
Fossils	4	0	0	0
Herringbone Cross Stratification	7	4	4	100
Hummocky Cross Stratification	6	1	1	100
Lenses	13	0	0	0
Lenticular Bedding	5	3	0	0
Lenticular Lamination	4	5	1	20
Planar/Parallel Bedding	26	10	1	10
Planar/Parallel Lamination	15	14	4	29
Structureless	24	12	4	33
Swaley Cross Stratification	2	0	0	0
Syneresis Cracks	2	0	0	0
Wave Ripples/Lamination	5	0	0	0
Wavy Bedding	2	3	1	33
Total	253	168	36	
Total Percentage of misclassifications for Test set, %				21

Table 6-10: Quantitative Results for the Detection of Sedimentary Structures on Core Images.

Experiments	Objective	Key Findings	Training Dataset/Data Type	Test Data Type	Backbone	Hyperparameter Setup
Experiment 1	Assess the suitability of YOLACT (DarkNet53) for outcrop geology segmentation	YOLACT is a suitable model for this task, but it often misclassifies image features and generates masks with significant overlap	Dataset 9 / Outcrop Images	Outcrop Images	DarkNet53	Table 7.
Experiment 2	Refine and improve segmentation outputs by modifying the YOLACT model	1)Using a shallower version of the Darknet53 backbone (cDarkNet53) improved the model's predictions. 2) Training the model separately on datasets 10a (for lithology) and 10b (for sedimentary structures) yields more interpretable results. 3)Higher dataset variability leads to better and more generalized results on unseen data.	Dataset 10a, 10b / Outcrop Images	Outcrop Images/Video	cDarkNet53	Table 7.
Experiment 3	Conduct a comparative study between YOLACT models with different backbones (cDarkNet53 and ResNet101)	YOLACT (ResNet101) offered slightly better accuracy and mask fit, while YOLACT (cDarkNet53) provided real-time predictions, faster inference, and FPS performance.	Dataset 10a, 10b / Outcrop Images	Outcrop Images	cDarkNet53, ResNet101	Table 7.
Experiment 4	Test the trained YOLACT (cDarkNet53) model on core images to assess its generalization ability	The YOLACT (cDarkNet53) model generalized well on core images without using any core images in training. The Instance Segmentation model demonstrated adaptability and good performance on diverse geological datasets.	-	Core Images/Video	cDarkNet53	

Table 7-2: Objective, key findings, training dataset/data type, test data type, backbone, and hyperparameter for each experiment.

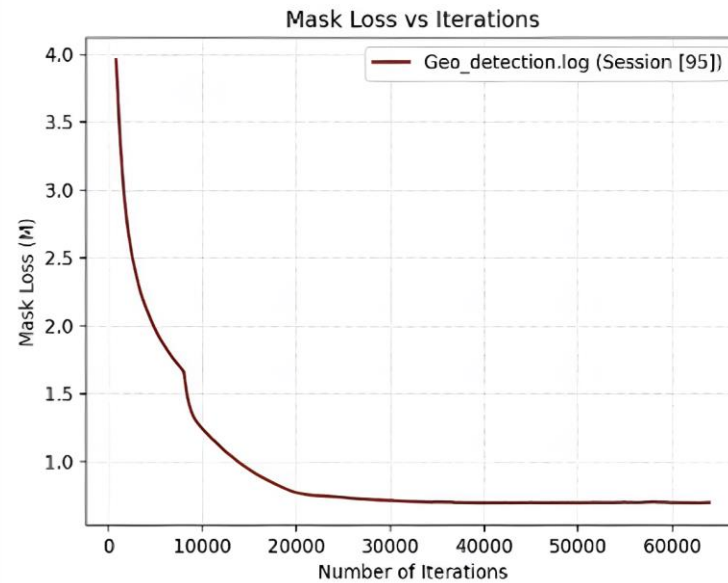
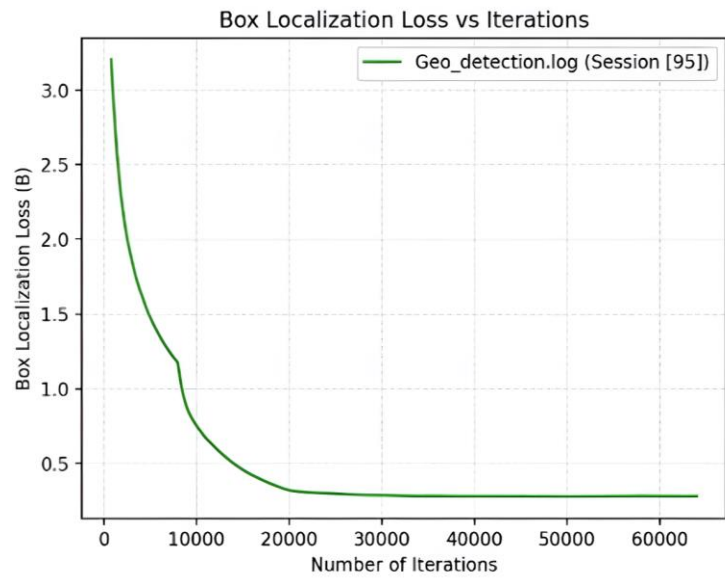


Figure 7-9: Overall Loss scores of classes confidence, masks, and bounding boxes on validation data versus the number of iterations/epochs.

Instance Segmentation Yolact for Lithology & Sedimentary Structures on Partially Seen Data

Labels/Classes	Label Count in Training and Validation Sets	Predicted Label Appearances in test data	Misclassifications per Label (Class)	Percentage of misclassifications per class
Planar_Bedding	13	22	2	9
Planar_Lamination	6	9	2	22
Cross_Bedding	5	7	3	43
Cross_Lamination	5	4	1	25
Interbedded_Sands	33	29	4	14
Erosive_Feature	34	25	5	20
Cemented_Sands_Eroded_Sands	10	18	7	39
Mudstones	79	52	4	8
Medium_to_Fine_Sandstone	1	6	2	33
Coarse_to_Medium_Sandstone	5	4	1	25
Conglomerate	50	33	4	12
Siltstone	3	3	0	0
Unconformity	12	9	6	67
Rip_up_clasts_Silty_sands	12	5	1	20
Sandstone	103	78	5	6
Total	371	304	47	
Total Percentage of misclassifications for Test set, %				15.5

Table 7-4: Quantitative Results of the default YOLACT model on partially seen outcrop images.

Instance Segmentation Yolact for Lithology & Sedimentary Structures on Unknown				
Labels/Classes	Label Count in Training and Validation Sets	Predicted Label Appearances in test data	Misclassifications per Label (Class)	Percentage of misclassifications per class
Planar_Bedding	13	10	4	40
Planar_Lamination	6	2	2	100
Cross_Bedding	5	4	0	0
Cross_Lamination	5	0	0	0
Interbedded_Sands	33	0	0	0
Erosive_Feature	34	0	0	0
Cemented_Sands_Eroded_Sands	10	10	9	90
Mudstones	79	0	0	0
Medium_to_Fine_Sandstone	1	0	0	0
Coarse_to_Medium_Sandstone	5	0	0	0
Conglomerate	50	0	0	0
Siltstone	3	0	0	0
Uncomformity	12	0	0	0
Rip_up_clasts_Silty_sands	12	3	2	67
Sandstone	103	0	0	0
Total	371	29	17	
Total Percentage of misclassifications for Test set, %				58.6

Table 7-5: Quantitative Results of the default YOLACT model on unknown outcrop images.

Training Image

Test Image

Segmented Outcrop

a)



Erosive Features
Sandstone
Conglomerate

b)



Interbedded Sands
Sandstone
Conglomerate

Figure 7-11: a) Instance Segmentation predictions, including a mask, bounding box, label, and the associated probability of the prediction on an Aeolian/Fluvial depositional environment. b) Instance Segmentation predictions, including a mask, bounding box, label, and the associated probability of the prediction on a Deep Marine depositional environment.

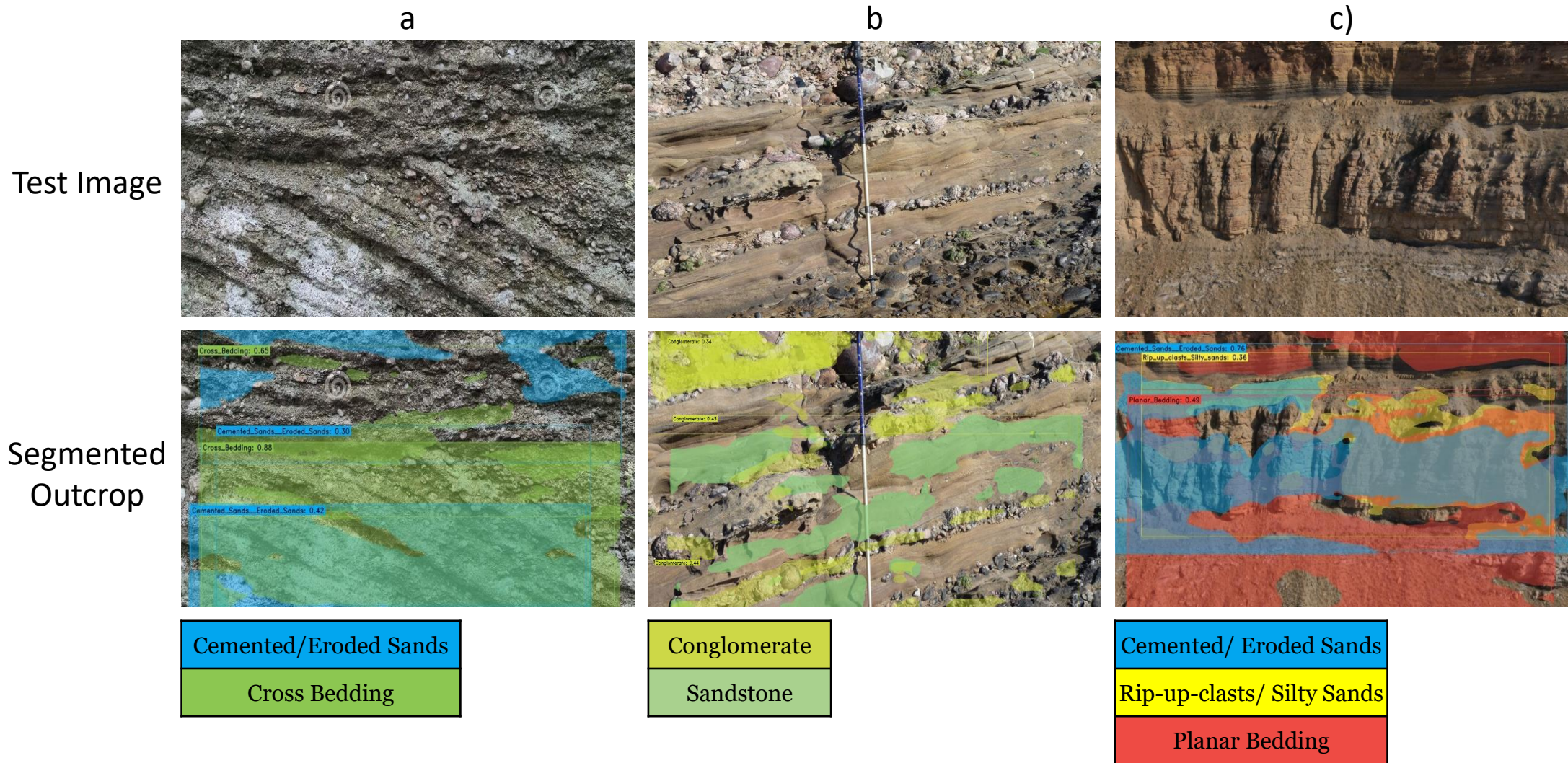


Figure 7-12: Instance Segmentation on unseen data demonstrating the model's performance getting worse as the test pictures are getting progressively different from the train set (from a to c).

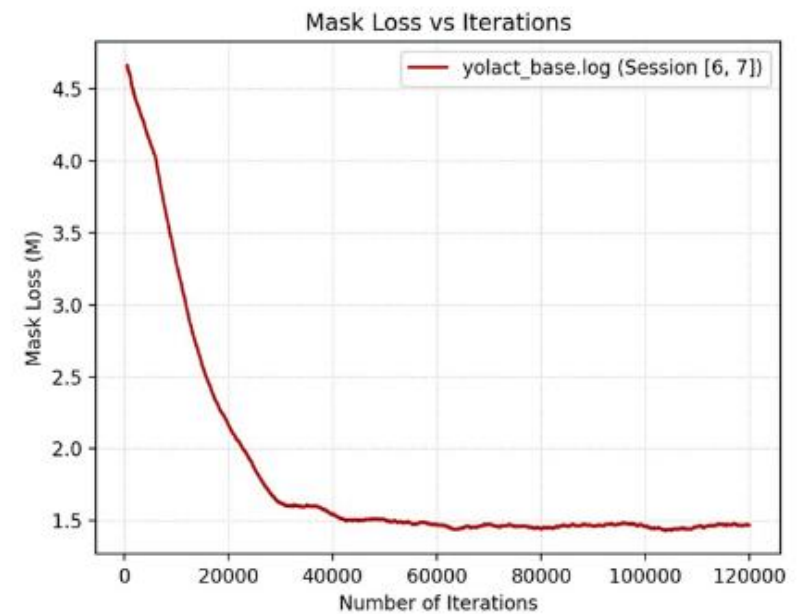
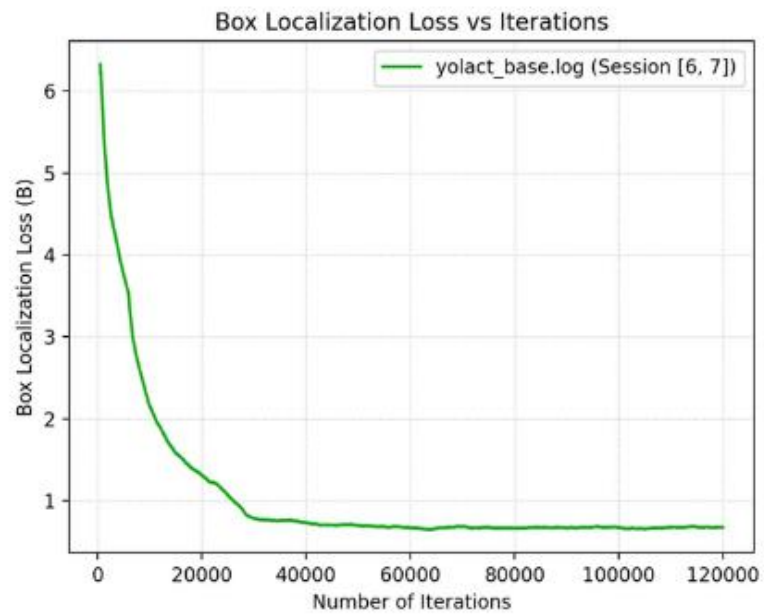
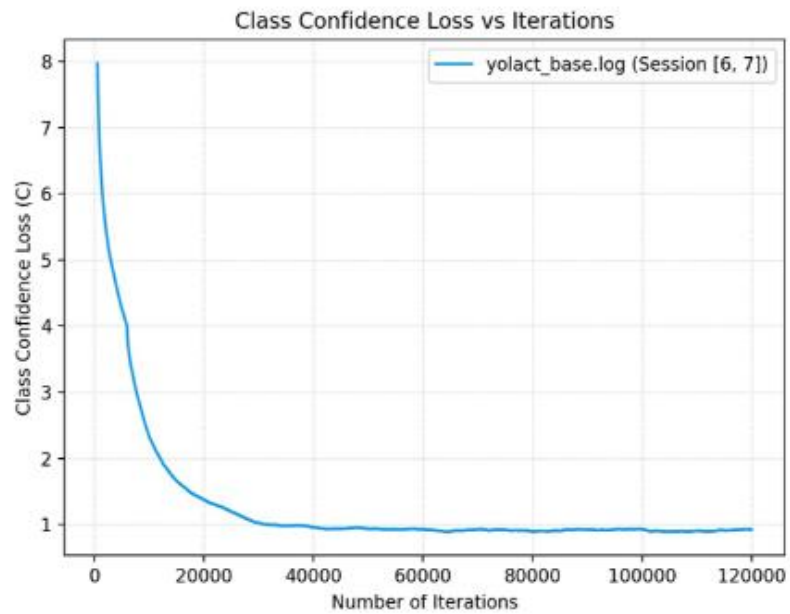


Figure 7-15: Overall Loss scores of classes confidence, masks, and bounding boxes on validation data versus the number of iterations/epochs.

Instance Segmentation Yolact for Lithology (cDarkNet53)				
Labels/Classes	Label Count in Training and Validation Sets	Predicted Label Appearances in test data	Misclassifications per Label (Class)	Percentage of misclassifications per class
Amalgamated/Cemented Bed	1	0	0	0
Breccia	5	5	0	0
Carbonates	7	6	0	0
Conglomerate	29	20	0	0
Interbedded mudstone-siltstone	27	20	1	5
Interbedded sandstone-mudstone	6	4	0	0
Interbedded sandstone-siltstone	21	21	1	5
Iron Rich Sediment	7	5	2	40
Mudstone	53	43	2	5
Organic Material	37	30	1	3
Red (Sandstone) Beds	21	21	0	0
Sandstone	79	71	1	1
Siltstone	28	23	1	4
Total	321	269	9	
Total Percentage of misclassifications for Test set, %				3.35

Table 7-7: Quantitative Results of the YOLACT (cDarkNet53) model. The model was trained on dataset 10a and tested on outcrop images to segment the various lithology types present.

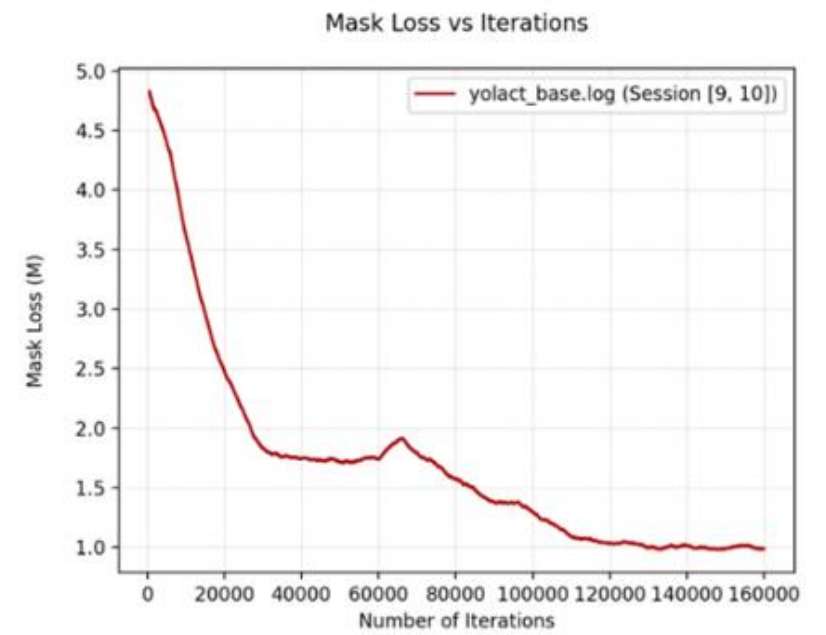
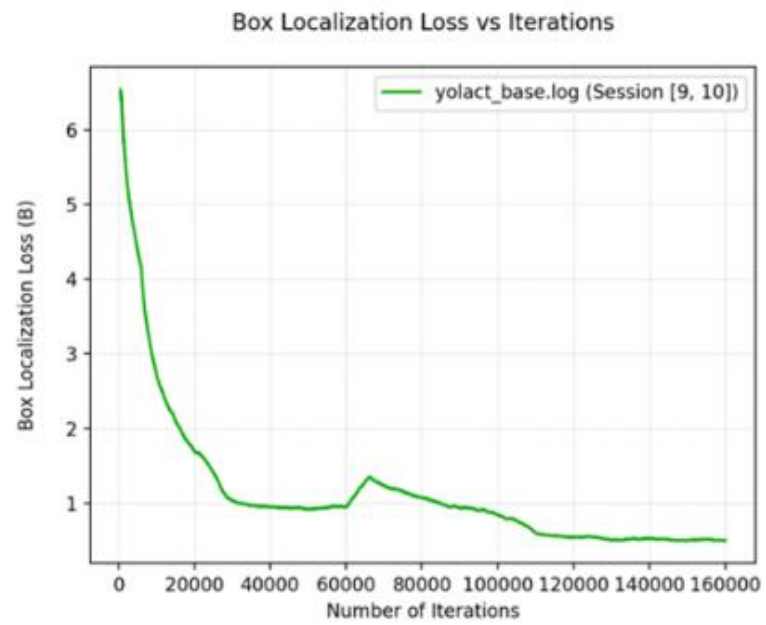
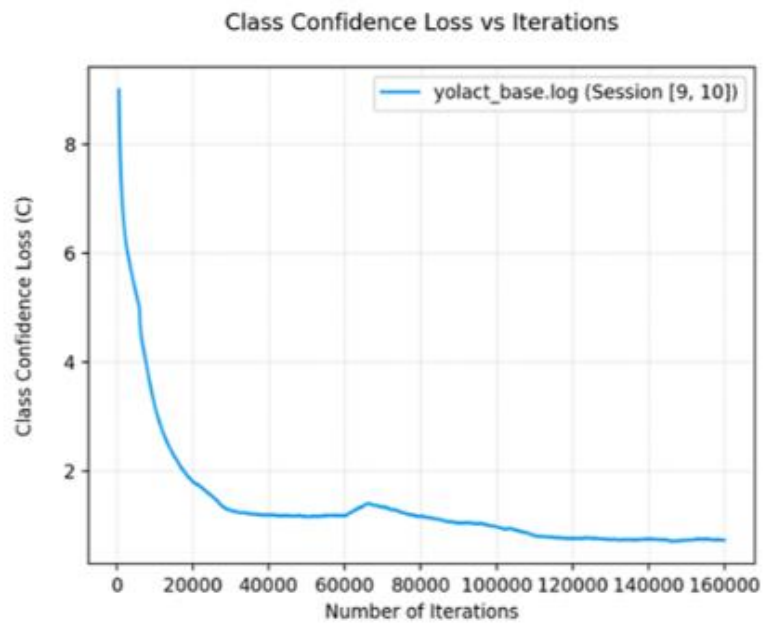


Figure 7-19: Overall Loss scores of classes confidence, masks, and bounding boxes on validation data versus the number of iterations/epochs.

Instance Segmentation Yolact for Sedimentary Structures (cDarkNet53)				
Labels/Classes	Label Count in Training and Validation Sets	Predicted Label Appearances in test data	Misclassifications per Label (Class)	Percentage of misclassifications per class, %
Bioturbation	48	32	0	0
Clasts	52	17	0	0
Convolute/Irregular Lamination	2	1	0	0
Convolute/Irregular Bedding	2	2	0	0
Cross Bedding/Stratification	39	34	8	24
Cross Lamination/Climbing Ripples	22	13	1	8
Dessication Cracks	5	4	0	0
Erosive Contacts/Bases	75	26	0	0
Erosive Features	31	10	1	10
Faults	16	7	0	0
Flame Structures	6	3	0	0
Flaser Lamination	3	2	2	100
Flute Marks	42	0	0	0
Fossils	12	12	0	0
Herringbone Cross Stratification	9	3	2	67
Hummocky Cross Stratification	10	2	0	0
Lenticular Bedding	8	4	0	0
Lenticular Lamination	5	3	0	0
Planar/Parallel Bedding	45	20	1	5
Planar/Parallel Lamination	29	18	2	11
Scour Marks	6	3	1	33
Structureless	56	33	1	3
Swaley Cross Stratification	4	1	0	0
Syneresis Cracks	2	4	3	75
Wave Ripples/Lamination	6	6	1	17
Wavy Bedding	5	3	0	0
Total	540	263	23	
Total Percentage of misclassifications for Test set, %				8.75

Table 7-9: Quantitative Results of the YOLACT (cDarkNet53) model. The model was trained on dataset 10b and tested on outcrop images to segment the various sedimentary structures present.

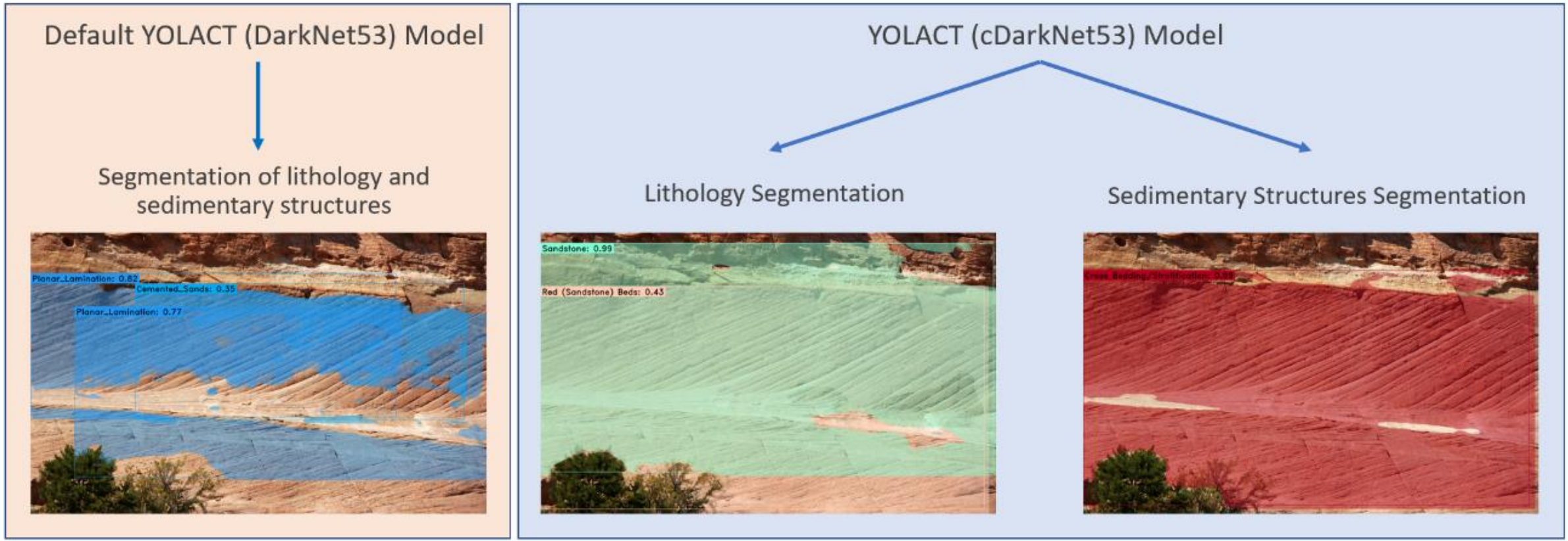


Figure 7-22: A comparison of the Default YOLACT (DarkNet53) Model vs. the YOLACT (cDarkNet53) on an unseen image.

Instance Segmentation Yolact for Lithology (ResNet101)				
Labels/Classes	Label Count in Training and Validation Sets	Predicted Label Appearances in test data	Misclassifications per Label (Class)	Percentage of misclassifications per class
Amalgamated/Cemented Bed	1	0	0	0
Breccia	5	5	0	0
Carbonates	7	8	0	0
Conglomerate	29	20	0	0
Interbedded mudstone-siltstone	27	31	2	6
Interbedded sandstone-mudstone	6	6	0	0
Interbedded sandstone-siltstone	21	27	2	7
Iron Rich Sediment	7	5	1	20
Mudstone	53	54	5	9
Organic Material	37	52	1	2
Red (Sandstone) Beds	21	23	3	13
Sandstone	79	82	3	4
Siltstone	28	35	4	11
Total	321	348	21	
Total Percentage of misclassifications for Test set, %				6

Table 7-10: Quantitative Results of the YOLACT (ResNet101) model. The model was trained on dataset 10b and tested on outcrop images to segment the various sedimentary structures present.

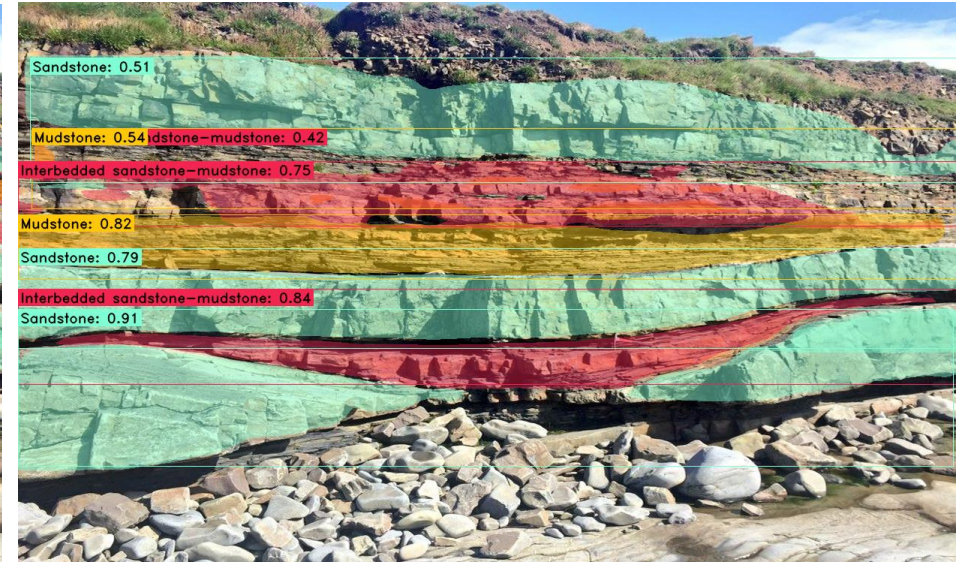
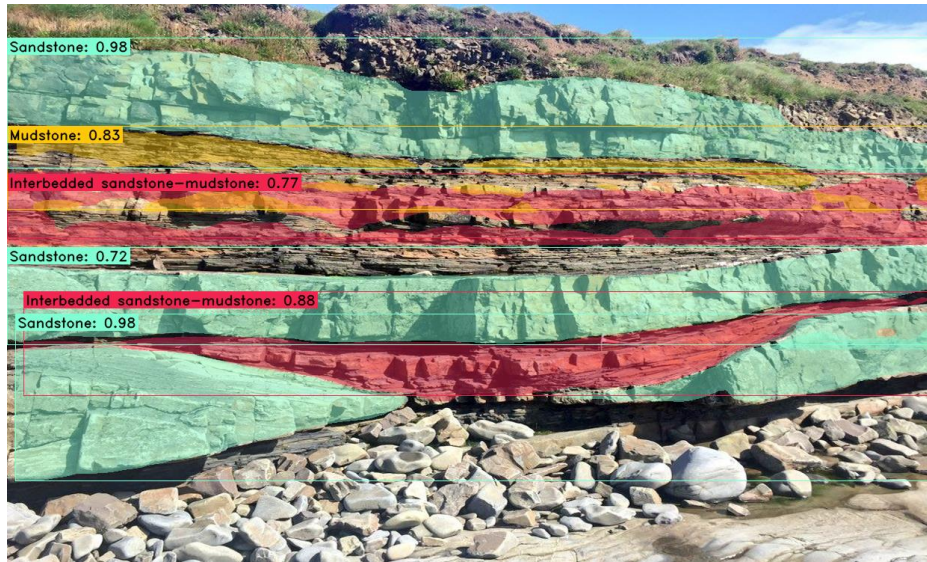
Instance Segmentation Yolact for Sedimentary Structures (ResNet101)				
Labels/Classes	Label Count in Training and Validation Sets	Predicted Label Appearances in test data	Misclassifications per Label (Class)	Percentage of misclassifications per class
Bioturbation	48	32	0	0
Clasts	52	16	0	0
Convolute/Irregular Lamination	2	1	0	0
Convolute/Irregular Bedding	2	2	0	0
Cross Bedding/Stratification	39	36	8	22
Cross Lamination/Climbing Ripples	22	13	1	8
Dessication Cracks	5	4	0	0
Erosive Contacts/Bases	75	27	0	0
Erosive Features	31	11	1	9
Faults	16	7	0	0
Flame Structures	6	3	0	0
Flaser Lamination	3	3	2	67
Flute Marks	42	0	0	0
Fossils	12	11	0	0
Herringbone Cross Stratification	9	3	2	67
Hummocky Cross Stratification	10	2	0	0
Lenticular Bedding	8	4	0	0
Lenticular Lamination	5	3	0	0
Planar/Parallel Bedding	45	23	1	4
Planar/Parallel Lamination	29	12	0	0
Scour Marks	6	2	1	50
Structureless	56	32	0	0
Swaley Cross Stratification	4	1	0	0
Syneresis Cracks	2	1	0	0
Wave Ripples/Lamination	6	7	1	14
Wavy Bedding	5	3	0	0
Total	540	259	17	
Total Percentage of misclassifications for Test set, %				6.56

Table 7-11: Quantitative Results of the YOLACT (ResNet101) model. The model was trained on dataset 10b and tested on outcrop images to segment the various sedimentary structures present.

cDarkNet53 Backbone

ResNet 101 Backbone

Lithology



Sedimentary Structures

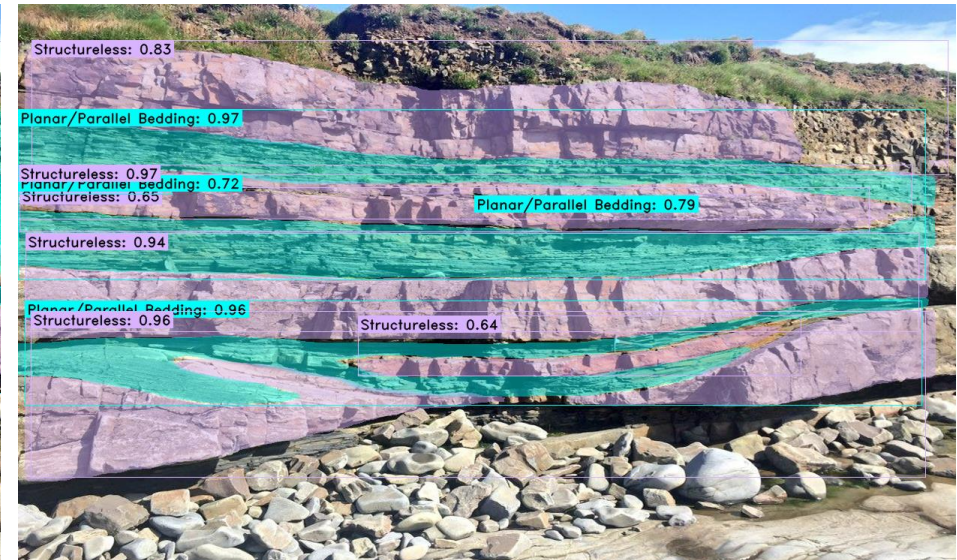
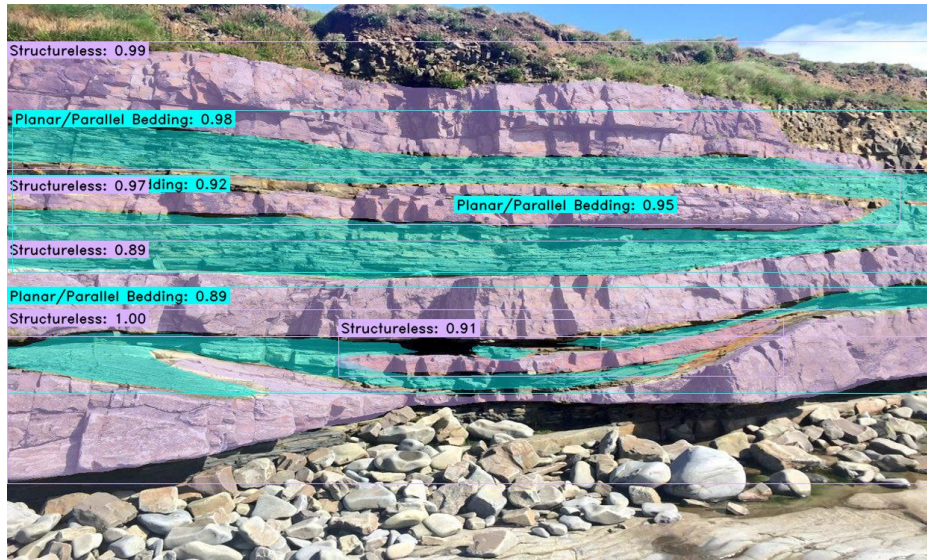
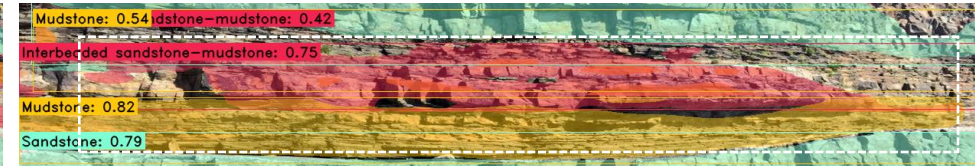
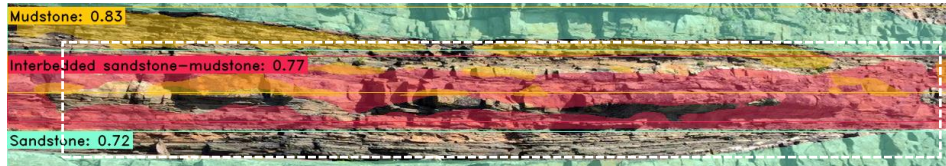


Figure 7-31: Backbone Comparison for the Lithology and Sedimentary structures models.

cDarkNet53 Backbone

ResNet 101 Backbone

Lithology



Sedimentary Structures

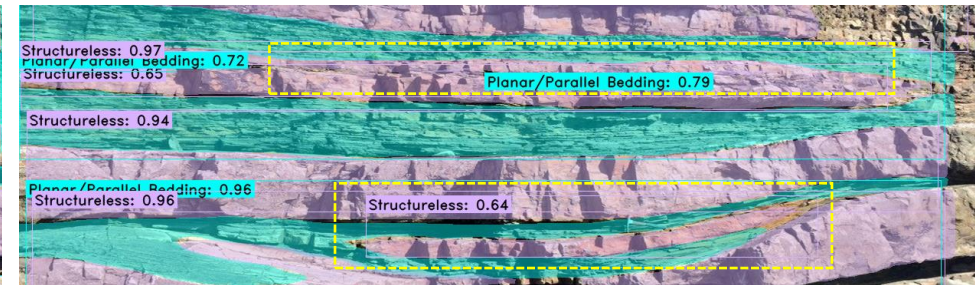
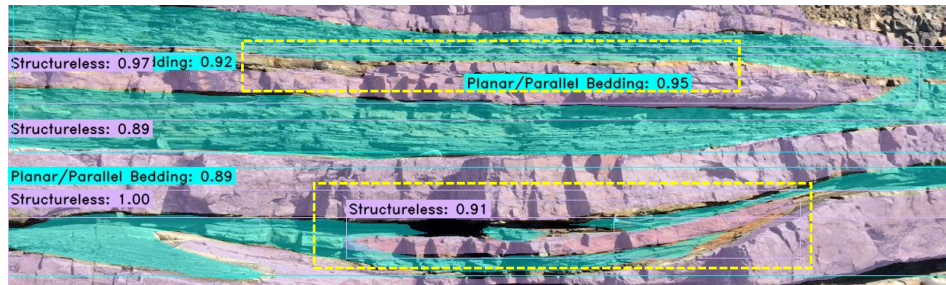


Figure 7-32: Backbone Comparison for the Lithology and Sedimentary Structures models depicted in more detail.

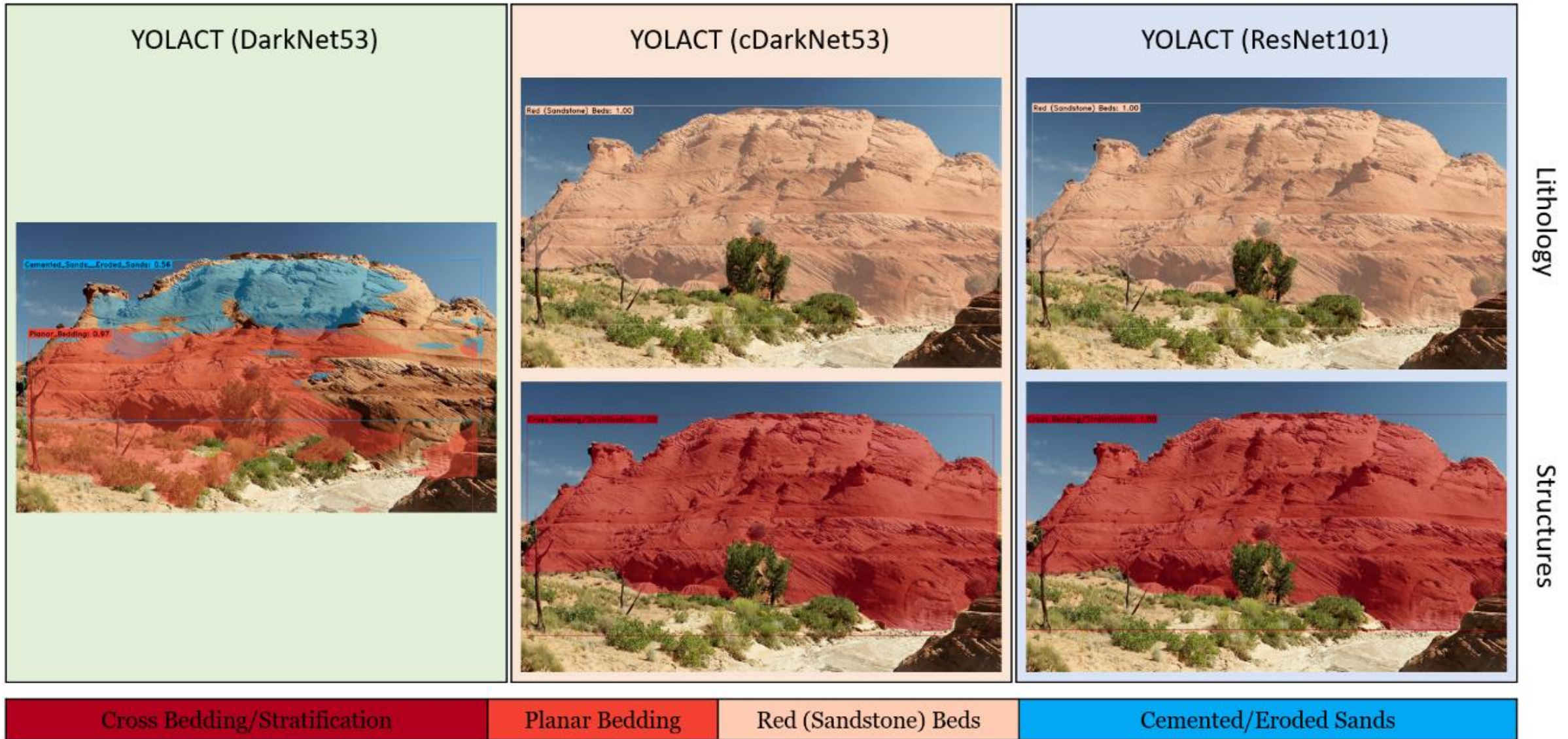


Figure 7-33: Comparison between all three models YOLACT (DarkNet53), YOLACT (cDarkNet53), and YOLACT (ResNet101) on a new outcrop image.

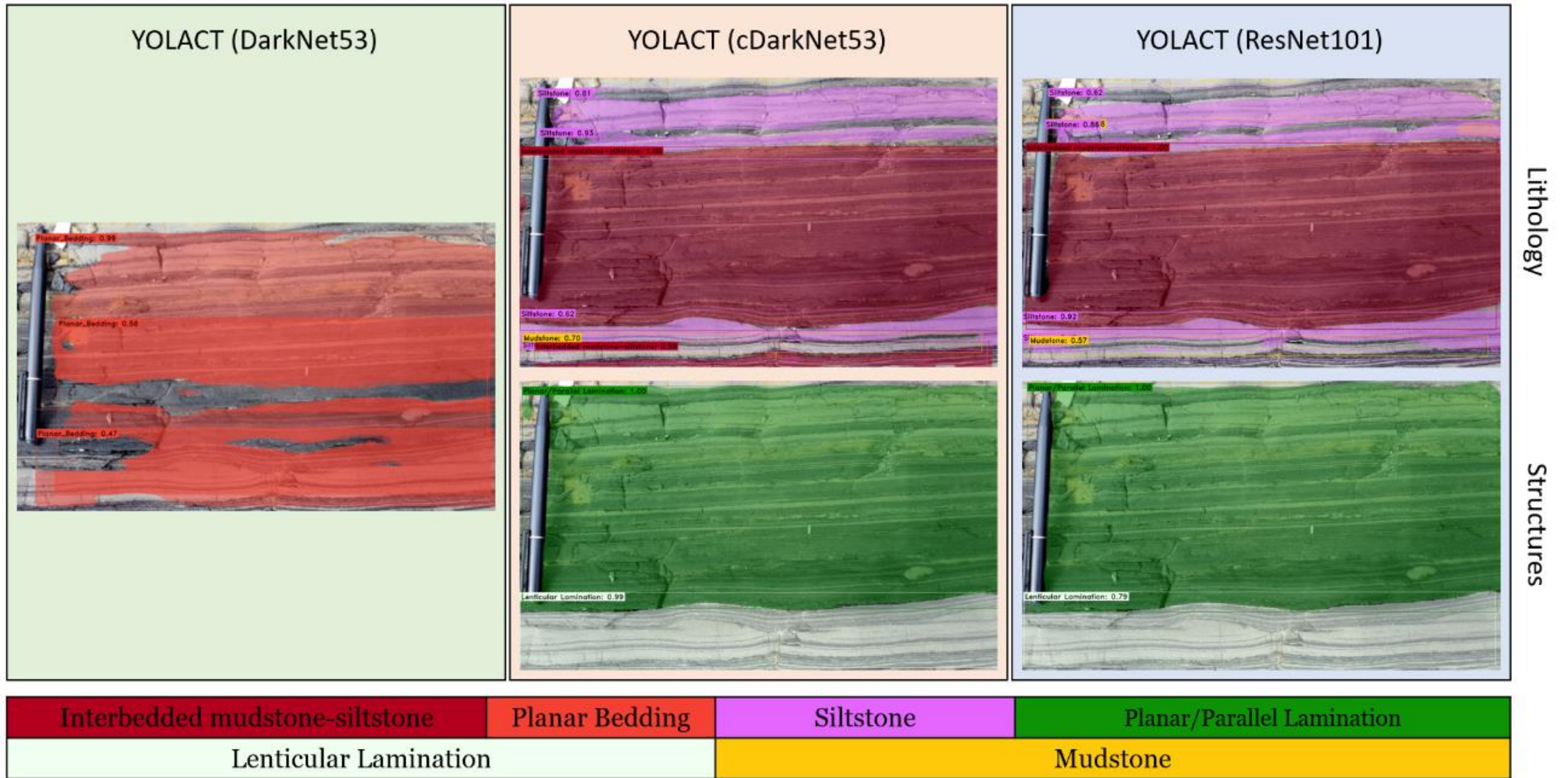


Figure 7-34: Comparison between all three models YOLACT (DarkNet53), YOLACT (cDarkNet53), and YOLACT (ResNet101) on another new outcrop image.

Select any number of PDF files

Remove graphics & non-text elements

Provide a file with keywords

Extract the keywords from each input PDF file into a single excel file

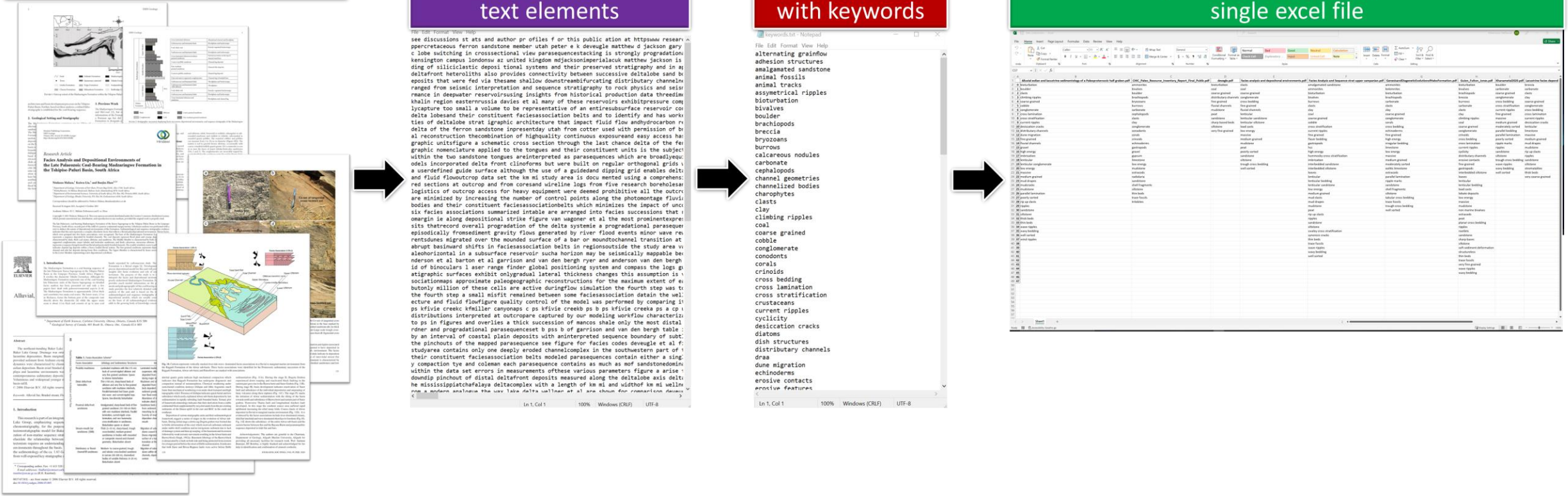


Figure 8-2: The main steps followed to extract the geological information from multiple pdf files into a single Excel file.

The screenshot displays the Geological Assisted Interpretation Application (G.A.I.A) interface. On the left, the 'Selections' panel includes categories: Environmental Characteristics (Medium grained, Alternating grainflow), Organisms-Fossil Content (Choose an option), Lithology (Red (Sandstone) beds, Sandstone), and Sedimentary Structures (Cross bedding, Draa, Mud drapes). An 'Update' button is at the bottom of this panel. A 'User's Input' box with arrows points to these selection fields. In the center, a large black box labeled 'Test Image Area' is shown. To the right, the 'Model's Output' box points to a JSON list of depositional environments and their probabilities. The application title 'Geological Assisted Interpretation Application (G.A.I.A)' is at the top right.

Geological Assisted Interpretation Application (G.A.I.A)

1) Depositional Environment Interpretation

The combination of ['Medium grained', 'Alternating grainflow', 'Red (Sandstone) beds', 'Sandstone', 'Cross bedding', 'Draa', 'Mud drapes'] indicates that the environment of deposition is most likely a Terrestrial environment and, more specifically, an Aeolian Environment with a probability of 1.0.

2) Multiple Scenarios of Depositional Environments

```
{
  "Aeolian" : "1.0"
  "Tidal Flat" : "0.134"
  "Proximal Delta" : "0.061"
  "Mudflat" : "0.026"
  "Coastal Bar Association" : "0.023"
  "Lacustrine Deposits" : "0.004"
  "Distal Delta" : "0.001"
  "Distributary or Fluvial Channel-Fill Sandstones" : "0.0"
  "Alluvial Fan" : "0.0"
  "Fluvial Environment" : "0.0"
  "Delta" : "0.0"
  "Ephemeral Saline Lake" : "0.0"
  "Perennial Saline to Fresh Lake" : "0.0"
  "Lagoon" : "0.0"
  "Shallow Marine" : "0.0"
  "Deep Marine" : "0.0"
  "Estuarine" : "0.0"
}
```

Figure 8-6: Sample of the Graphical User Interface layout with the fields and outputs.

localhost:8501
Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics
Choose an option

Organisms-Fossil Content
Choose an option

Lithology

Interbedded mudst... x

Interbedded siltstone x

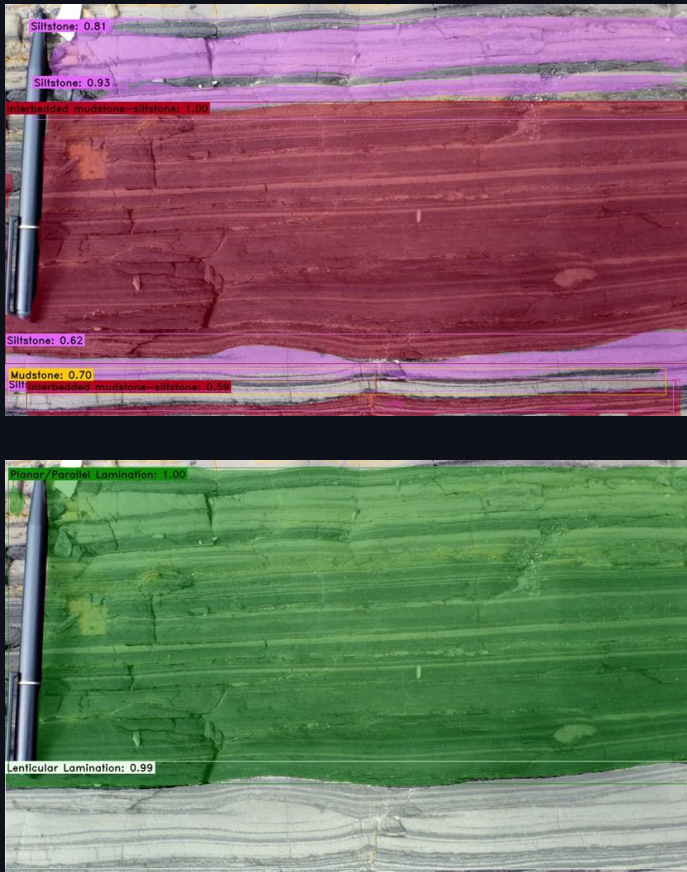
Mudstone x Siltstone x

Sedimentary Structures

Lenticular lamination x

Planar lamination x

Update



1) Depositional Environment Interpretation

The combination of ['Interbedded mudstone', 'Interbedded siltstone', 'Mudstone', 'Siltstone', 'Lenticular lamination', 'Planar lamination'] indicates that the environment of deposition is most likely a Marine environment, and more specifically, a Deep Marine Environment with a probability of 0.999.

2) Multiple Scenarios of Depositional Environments

```
{
  "Deep Marine" : "0.999"
  "Delta" : "0.966"
  "Lacustrine Deposits" : "0.001"
  "Distributary or Fluvial Channel-Fill Sandstones" : "0.0"
  "Alluvial Fan" : "0.0"
  "Fluvial Environment" : "0.0"
  "Proximal Delta" : "0.0"
  "Distal Delta" : "0.0"
  "Mudflat" : "0.0"
  "Ephemeral Saline Lake" : "0.0"
  "Perennial Saline to Fresh Lake" : "0.0"
  "Lagoon" : "0.0"
  "Aeolian" : "0.0"
  "Shallow Marine" : "0.0"
  "Coastal Bar Association" : "0.0"
}
```

Figure 8-7: Example 1 of the GUI model's predictions based on outcrop images.

localhost:8501
Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

Choose an option

Organisms-Fossil Content

Choose an option

Lithology

Interbedded mudst... ✕

Interbedded siltstone ✕

Mudstone ✕ Siltstone ✕

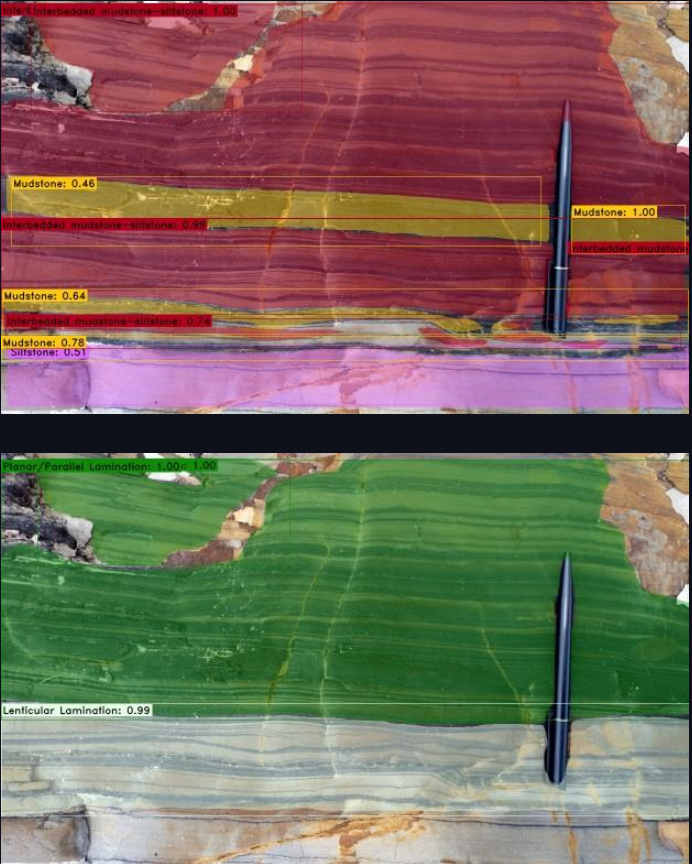
Sedimentary Structures

Lenticular lamination ✕

Planar lamination ✕

Parallel lamination ✕

Update



1) Depositional Environment Interpretation

The combination of ['Interbedded mudstone', 'Interbedded siltstone', 'Mudstone', 'Siltstone', 'Lenticular lamination', 'Planar lamination', 'Parallel lamination'] indicates that the environment of deposition is most likely a Marine environment, and more specifically, a Deep Marine Environment with a probability of 0.993.

2) Multiple Scenarios of Depositional Environments

```

{
  "Deep Marine" : "0.993"
  "Delta" : "0.891"
  "Fluvial Environment" : "0.003"
  "Lacustrine Deposits" : "0.003"
  "Shallow Marine" : "0.001"
  "Distributary or Fluvial Channel-Fill Sandstones" : "0.0"
  "Alluvial Fan" : "0.0"
  "Proximal Delta" : "0.0"
  "Distal Delta" : "0.0"
  "Mudflat" : "0.0"
  "Ephemeral Saline Lake" : "0.0"
  "Perennial Saline to Fresh Lake" : "0.0"
  "Lagoon" : "0.0"
  "Aeolian" : "0.0"
  "Coastal Bar Association" : "0.0"
}

```

Figure 8-8: Example 2 of the GUI model's predictions based on outcrop images.

localhost:8501
Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

- Erosive Contacts/Bases
- Erosive Features

Organisms-Fossil Content

Choose an option

Lithology

- Conglomerate
- Sandstone
- Mudstone
- Red (Sandstone) beds

Sedimentary Structures

- Parallel bedding

Update

1) Depositional Environment Interpretation

The combination of ['Erosive Contacts/Bases', 'Erosive Features', 'Conglomerate', 'Sandstone', 'Mudstone', 'Red (Sandstone) beds', 'Parallel bedding'] indicates that the environment of deposition is most likely a Terrestrial environment and, more specifically, a Fluvial Environment with a probability of 1.0.

2) Multiple Scenarios of Depositional Environments

```

{
  "Fluvial Environment" : "1.0"
  "Aeolian" : "0.273"
  "Coastal Bar Association" : "0.001"
  "Distributary or Fluvial Channel-Fill Sandstones" : "0.0"
  "Alluvial Fan" : "0.0"
  "Delta" : "0.0"
  "Proximal Delta" : "0.0"
  "Distal Delta" : "0.0"
  "Lacustrine Deposits" : "0.0"
  "Mudflat" : "0.0"
  "Ephemeral Saline Lake" : "0.0"
  "Perennial Saline to Fresh Lake" : "0.0"
  "Lagoon" : "0.0"
  "Shallow Marine" : "0.0"
  "Deep Marine" : "0.0"
}

```

Figure 8-9: Example 3 of the GUI model's predictions based on outcrop images.

localhost:8501

Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

Erosive Contacts/Bases ✕

Erosive Features ✕

Organisms-Fossil Content

Choose an option ▾

Lithology

Sandstone ✕

Mudstone ✕

Red (Sandstone) beds ✕

Sedimentary Structures

Parallel bedding ✕

Cross bedding ✕

Update

1) Depositional Environment Interpretation

The combination of ['Erosive Contacts/Bases', 'Erosive Features', 'Sandstone', 'Mudstone', 'Red (Sandstone) beds', 'Parallel bedding', 'Cross bedding'] indicates that the environment of deposition is most likely a Terrestrial environment and, more specifically, a Fluvial Environment with a probability of 1.0.

2) Multiple Scenarios of Depositional Environments

```

{
  "Fluvial Environment" : "1.0"
  "Aeolian" : "0.554"
  "Coastal Bar Association" : "0.004"
  "Distributary or Fluvial Channel-Fill Sandstones" : "0.0"
  "Alluvial Fan" : "0.0"
  "Delta" : "0.0"
  "Proximal Delta" : "0.0"
  "Distal Delta" : "0.0"
  "Lacustrine Deposits" : "0.0"
  "Mudflat" : "0.0"
  "Ephemeral Saline Lake" : "0.0"
  "Perennial Saline to Fresh Lake" : "0.0"
  "Lagoon" : "0.0"
  "Shallow Marine" : "0.0"
  "Deep Marine" : "0.0"
}

```

Figure 8-10: Example 4 of the GUI model's predictions based on outcrop images.

localhost:8501
Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

- Erosive Contacts/Bases X
- Erosive Features X
- Clasts X

Organisms-Fossil Content

Choose an option

Lithology

- Sandstone X
- Mudstone X
- Conglomerate X
- Siltstone X

Sedimentary Structures

- Parallel bedding X
- Cross bedding X

Update

1) Depositional Environment Interpretation

The combination of ['Erosive Contacts/Bases', 'Erosive Features', 'Clasts', 'Sandstone', 'Mudstone', 'Conglomerate', 'Siltstone', 'Parallel bedding', 'Cross bedding'] indicates that the environment of deposition is most likely a Terrestrial environment and, more specifically, a Fluvial Environment with a probability of 1.0.

2) Multiple Scenarios of Depositional Environments

```

{
  "Fluvial Environment" : "1.0"
  "Delta" : "0.028"
  "Distributary or Fluvial Channel-Fill Sandstones" : "0.0"
  "Alluvial Fan" : "0.0"
  "Proximal Delta" : "0.0"
  "Distal Delta" : "0.0"
  "Lacustrine Deposits" : "0.0"
  "Mudflat" : "0.0"
  "Ephemeral Saline Lake" : "0.0"
  "Perennial Saline to Fresh Lake" : "0.0"
  "Lagoon" : "0.0"
  "Aeolian" : "0.0"
  "Shallow Marine" : "0.0"
  "Coastal Bar Association" : "0.0"
  "Deep Marine" : "0.0"
}

```

Figure 8-12: Example 6 of the GUI model's predictions based on core images.

Isona

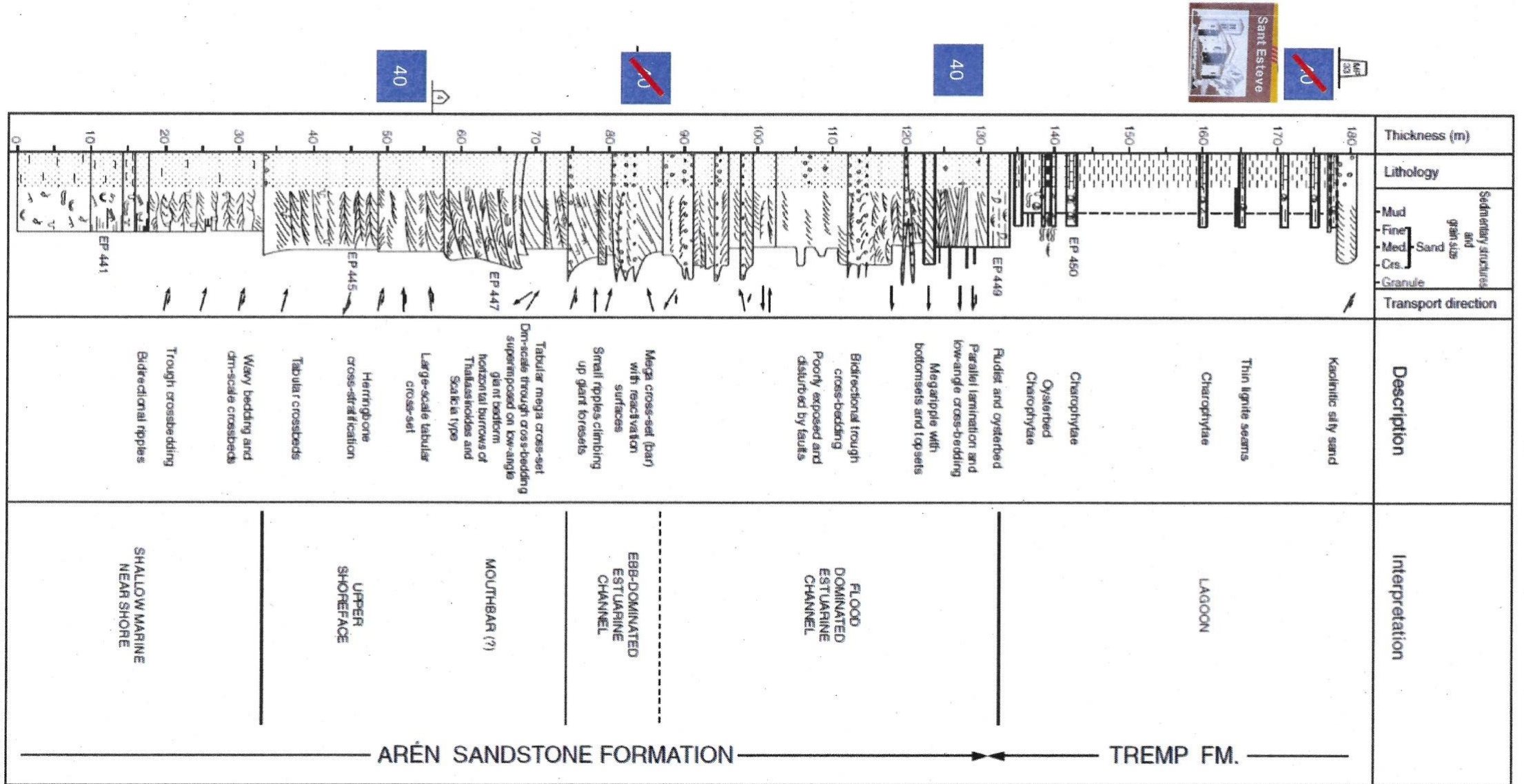


Figure 8-13: Sedimentary log of the Isona outcrop.

localhost:8501
Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

Bidirectional ✕

Fine grained ✕

Organisms-Fossil Content

Choose an option ▼

Lithology

Sandstone ✕

Sedimentary Structures

Ripples ✕

Trough cross bedding ✕

Update

Thickness (m)	Lithology	Sedimentary structures and grain size	Transport direction	Description	Interpretation
30	Mud	Fine	↗ ↘	Wavy bedding and dm-scale crossbeds	SHALLOW MARINE NEAR SHORE
20	Med	Sand	↗ ↘	Trough crossbedding	
10	Sand	Gr	↗ ↘	Bidirectional ripples	
0	EP 441				

1) Depositional Environment Interpretation

The combination of ['Bidirectional', 'Fine grained', 'Sandstone', 'Ripples', 'Trough cross bedding'] indicates that the environment of deposition is most likely a Marine environment and, more specifically, a Shallow Marine Environment with a probability of 0.98.

2) Multiple Scenarios of Depositional Environments

```

{
  "Shallow Marine": "0.98"
  "Coastal Bar Association": "0.384"
  "Estuarine": "0.316"
  "Aeolian": "0.001"
  "Distributary or Fluvial Channel-Fill Sandstones": "0.0"
  "Alluvial Fan": "0.0"
  "Fluvial Environment": "0.0"
  "Delta": "0.0"
  "Proximal Delta": "0.0"
  "Distal Delta": "0.0"
  "Lacustrine Deposits": "0.0"
  "Mudflat": "0.0"
  "Ephemeral Saline Lake": "0.0"
  "Perennial Saline to Fresh Lake": "0.0"
  "Lagoon": "0.0"
  "Deep Marine": "0.0"
  "Tidal Flat": "0.0"
}

```

Figure 8-14: Example 7 of the GUI model's predictions based on sedimentary logs.

← → ↻ localhost:8501
✕

Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

Coarse grained ✕

Medium grained ✕

Organisms-Fossil Content

Choose an option ▾

Lithology

Sandstone ✕

Sedimentary Structures

Tabular cross beddi... ✕

Herringbone cross... ✕

Update

Thickness (m)	Lithology	Sedimentary structures and grain size	Transport direction	Description	Interpretation
50		Large-scale tabular cross-set	→	Large-scale tabular cross-set	UPPER SHOREFACE
40		Herringbone cross-stratification (EP 445)	↗ ↘	Herringbone cross-stratification	
		Tabular crossbeds	→	Tabular crossbeds	

1) Depositional Environment Interpretation

The combination of ['Coarse grained', 'Medium grained', 'Sandstone', 'Tabular cross bedding', 'Herringbone cross-stratification'] indicates that the environment of deposition is most likely a Marine environment and, more specifically, a Shallow Marine Environment with a probability of 1.0.

2) Multiple Scenarios of Depositional Environments

```

{
  "Shallow Marine" : "1.0"
  "Fluvial Environment" : "0.985"
  "Tidal Flat" : "0.849"
  "Aeolian" : "0.433"
  "Coastal Bar Association" : "0.048"
  "Estuarine" : "0.002"
  "Deep Marine" : "0.001"
  "Distributary or Fluvial Channel-Fill Sandstones" : "0.0"
  "Alluvial Fan" : "0.0"
  "Delta" : "0.0"
  "Proximal Delta" : "0.0"
  "Distal Delta" : "0.0"
  "Lacustrine Deposits" : "0.0"
  "Mudflat" : "0.0"
  "Ephemeral Saline Lake" : "0.0"
  "Perennial Saline to Fresh Lake" : "0.0"
  "Lagoon" : "0.0"
}

```

Figure 8-15: Example 8 of the GUI model's predictions based on sedimentary logs.

localhost:8501
Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

Coarse grained ✕

Medium grained ✕

Organisms-Fossil Content

Burrows ✕

Lithology

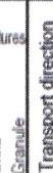
Sandstone ✕

Sedimentary Structures

Tabular cross beddi... ✕

Trough cross bedding ✕

Update

Thickness (m)	Lithology	Sedimentary structures and grain sizes	Transport direction	Description	Interpretation
70 60		Mud Fine Med Sand Co. Granule		Tabular mega cross-set Dm-scale through cross-bedding superimposed on low-angle giant bedform horizontal burrows of Thalassinoides and Scolicia type	MOUTHBAR (?)

1) Depositional Environment Interpretation

The combination of ['Coarse grained', 'Medium grained', 'Burrows', 'Sandstone', 'Tabular cross bedding', 'Trough cross bedding'] indicates that the environment of deposition is most likely a Terrestrial environment and, more specifically, a Fluvial Environment with a probability of 0.937.

2) Multiple Scenarios of Depositional Environments

```

{
  "Fluvial Environment" : "0.937"
  "Lacustrine Deposits" : "0.915"
  "Aeolian" : "0.603"
  "Distributary or Fluvial Channel-Fill Sandstones" : "0.578"
  "Coastal Bar Association" : "0.034"
  "Estuarine" : "0.031"
  "Ephemeral Saline Lake" : "0.015"
  "Delta" : "0.013"
  "Tidal Flat" : "0.007"
  "Mudflat" : "0.002"
  "Perennial Saline to Fresh Lake" : "0.002"
  "Shallow Marine" : "0.001"
  "Alluvial Fan" : "0.0"
  "Proximal Delta" : "0.0"
  "Distal Delta" : "0.0"
  "Lagoon" : "0.0"
  "Deep Marine" : "0.0"
}
          
```

Figure 8-16: Example 9 of the GUI model's predictions based on sedimentary logs.

Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

Coarse grained ✕

Medium grained ✕

Very coarse grained ✕

Gravel ✕

Reactivation surfaces ✕

Foresets ✕

Organisms-Fossil Content

Choose an option ▾

Lithology

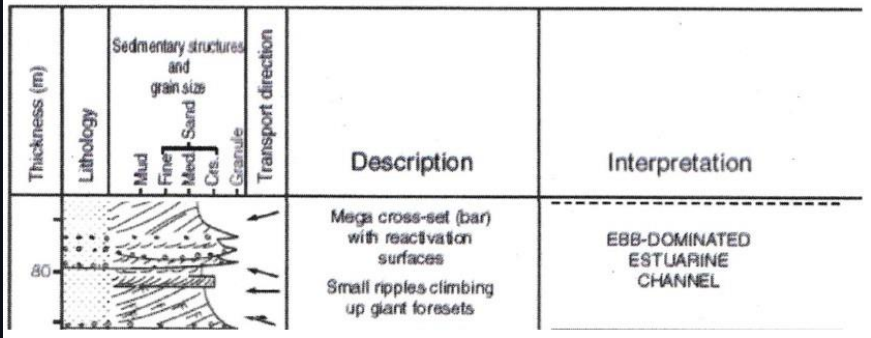
Sandstone ✕

Conglomerate ✕

Sedimentary Structures

Climbing ripples ✕

Update



Thickness (m)	Lithology	Sedimentary structures and grain sizes	Transport direction	Description	Interpretation
80				Mega cross-set (bar) with reactivation surfaces Small ripples climbing up giant foresets	EBB-DOMINATED ESTUARINE CHANNEL

1) Depositional Environment Interpretation

The combination of ['Coarse grained', 'Medium grained', 'Very coarse grained', 'Gravel', 'Reactivation surfaces', 'Foresets', 'Sandstone', 'Conglomerate', 'Climbing ripples'] indicates that the environment of deposition is most likely a Marine environment and, more specifically, a Shallow Marine Environment with a probability of 0.999.

2) Multiple Scenarios of Depositional Environments

```

{
  "Shallow Marine": "0.999"
  "Estuarine": "0.999"
  "Coastal Bar Association": "0.998"
  "Deep Marine": "0.692"
  "Fluvial Environment": "0.001"
  "Tidal Flat": "0.001"
  "Distributary or Fluvial Channel-Fill Sandstones": "0.0"
  "Alluvial Fan": "0.0"
  "Delta": "0.0"
  "Proximal Delta": "0.0"
  "Distal Delta": "0.0"
  "Lacustrine Deposits": "0.0"
  "Mudflat": "0.0"
  "Ephemeral Saline Lake": "0.0"
  "Perennial Saline to Fresh Lake": "0.0"
  "Lagoon": "0.0"
  "Aeolian": "0.0"
}

```

Figure 8-17: Example 10 of the GUI model's predictions based on sedimentary logs.

Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

Coarse grained ✕

Medium grained ✕

Gravel ✕

Bottomsets ✕

Topsets ✕

Bidirectional ✕

Organisms-Fossil Content

Choose an option

Lithology

Sandstone ✕

Conglomerate ✕

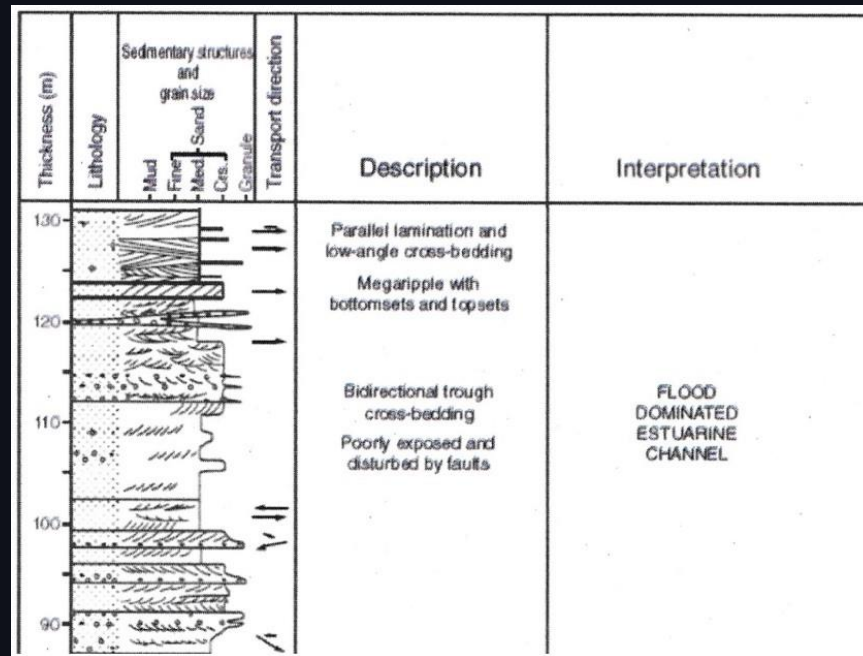
Sedimentary Structures

Cross bedding ✕

Parallel lamination ✕

Trough cross bedding ✕

Update



1) Depositional Environment Interpretation

The combination of ['Coarse grained', 'Medium grained', 'Gravel', 'Bottomsets', 'Topsets', 'Bidirectional', 'Sandstone', 'Conglomerate', 'Cross bedding', 'Parallel lamination', 'Trough cross bedding'] indicates that the environment of deposition is most likely a Transitional environment and, more specifically, an Estuarine with a probability of 1.0.

2) Multiple Scenarios of Depositional Environments

```
{
  "Estuarine": "1.0"
  "Coastal Bar Association": "0.986"
  "Shallow Marine": "0.982"
  "Fluvial Environment": "0.008"
  "Tidal Flat": "0.006"
  "Aeolian": "0.004"
  "Ephemeral Saline Lake": "0.001"
  "Distributary or Fluvial Channel-Fill Sandstones": "0.0"
  "Alluvial Fan": "0.0"
  "Delta": "0.0"
  "Proximal Delta": "0.0"
  "Distal Delta": "0.0"
  "Lacustrine Deposits": "0.0"
  "Mudflat": "0.0"
  "Perennial Saline to Fresh Lake": "0.0"
  "Lagoon": "0.0"
  "Deep Marine": "0.0"
}
```

Figure 8-18: Example 11 of the GUI model's predictions based on sedimentary logs.

localhost:8501

Geological Assisted Interpretation Application (G.A.I.A)

Selections

Environmental Characteristics

Coarse grained ✕

Medium grained ✕

Fine grained ✕

Very fine grained ✕

Thin beds ✕

Organisms-Fossil Content

Charophytes ✕ Rudists ✕

Lithology

Sandstone ✕ Mudstone ✕

Siltstone ✕

Sedimentary Structures

Choose an option

Update

Thickness (m)	Lithology	Sedimentary structures and grain size	Transport direction	Description	Interpretation
180				Kaolinitic silty sand	LAGOON
170				Thin lignite seams	
160				Charophytae	
150				Charophytae	
140				Oysterbed Charophytae	
				Rudist and oysterbed	

1) Depositional Environment Interpretation

The combination of ['Coarse grained', 'Medium grained', 'Fine grained', 'Very fine grained', 'Thin beds', 'Charophytes', 'Rudists', 'Sandstone', 'Mudstone', 'Siltstone'] indicates that the environment of deposition is most likely a Marine environment and, more specifically, a Lagoonal Environment with a probability of 1.0.

2) Multiple Scenarios of Depositional Environments

```

{
  "Lagoon": "1.0"
  "Deep Marine": "0.177"
  "Lacustrine Deposits": "0.002"
  "Tidal Flat": "0.001"
  "Distributary or Fluvial Channel-Fill Sandstones": "0.0"
  "Alluvial Fan": "0.0"
  "Fluvial Environment": "0.0"
  "Delta": "0.0"
  "Proximal Delta": "0.0"
  "Distal Delta": "0.0"
  "Mudflat": "0.0"
  "Ephemeral Saline Lake": "0.0"
  "Perennial Saline to Fresh Lake": "0.0"
  "Aeolian": "0.0"
  "Shallow Marine": "0.0"
  "Coastal Bar Association": "0.0"
  "Estuarine": "0.0"
}

```

Figure 8-19: Example 12 of the GUI model's predictions based on sedimentary logs.