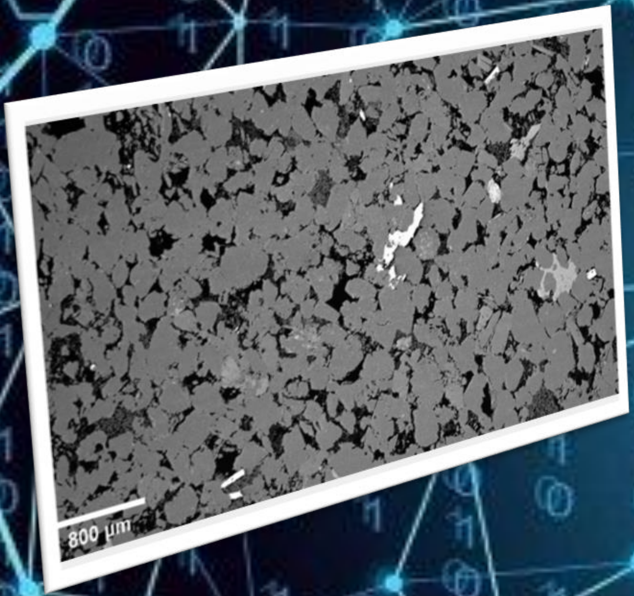
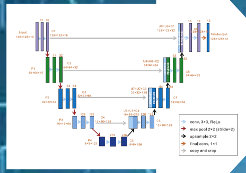
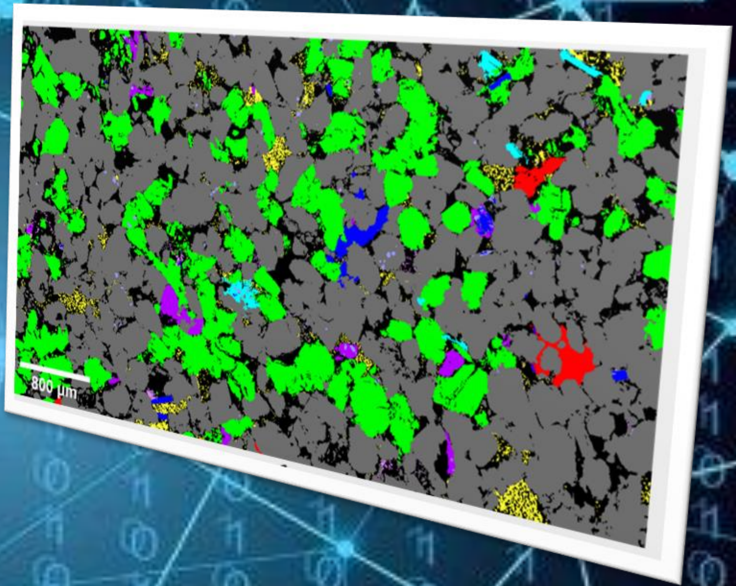


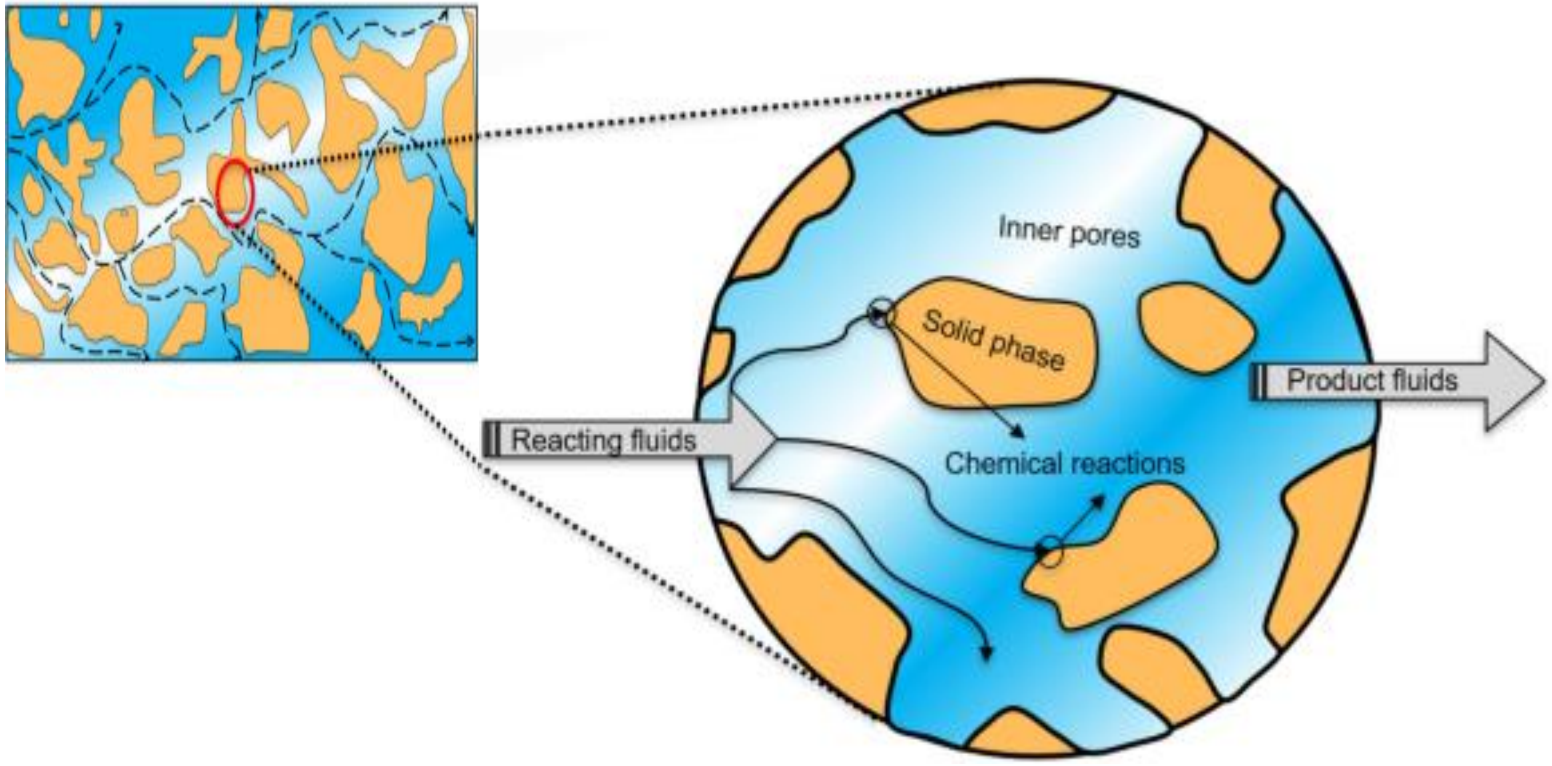



Machine/Deep Learning Methods for Pore-Mineral Characterization and Surface Areas Analysis.

Parisa Asadi & Lauren E. Beckingham
Department of Civil and Environmental Engineering
Auburn University

Introduction

- Acidification and contamination via trace element mobilization [1-5] threaten groundwater.
- Reactions can **alter formation and caprock properties** and may **increase fracture or formation permeability**.



https://link.springer.com/article/10.1007/s42452-021-04396-9

Why Imaging and Machine Learning Techniques

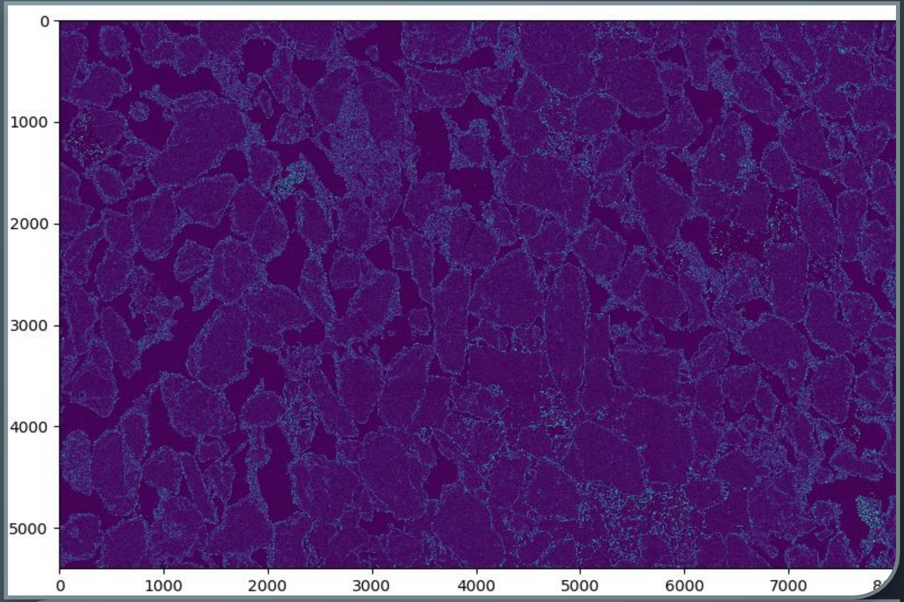
- Imaging is a powerful technique for mineral segmentation and sample characterization.

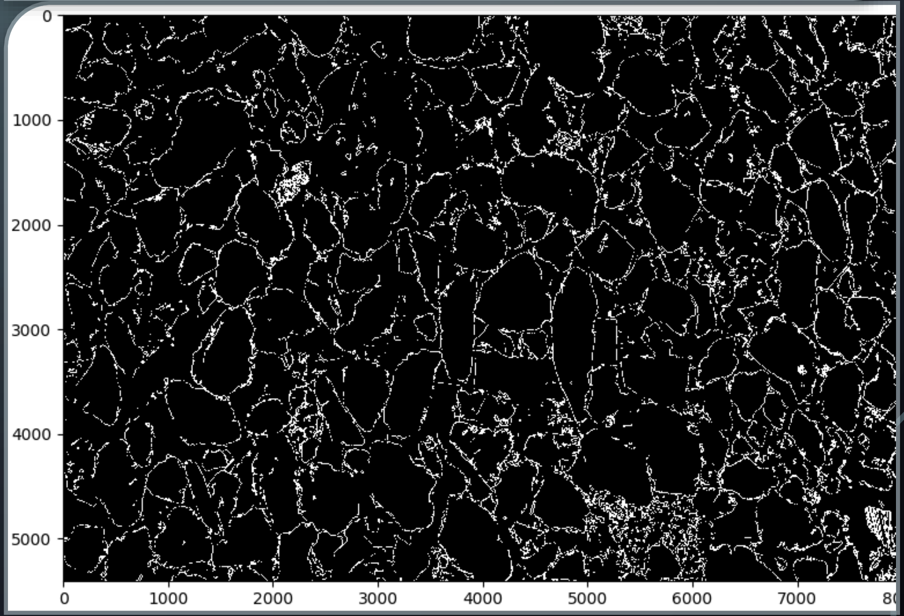
✓time-consuming

✓labor-intensive

✓subjective

- It can consider several extracted features at the same time.

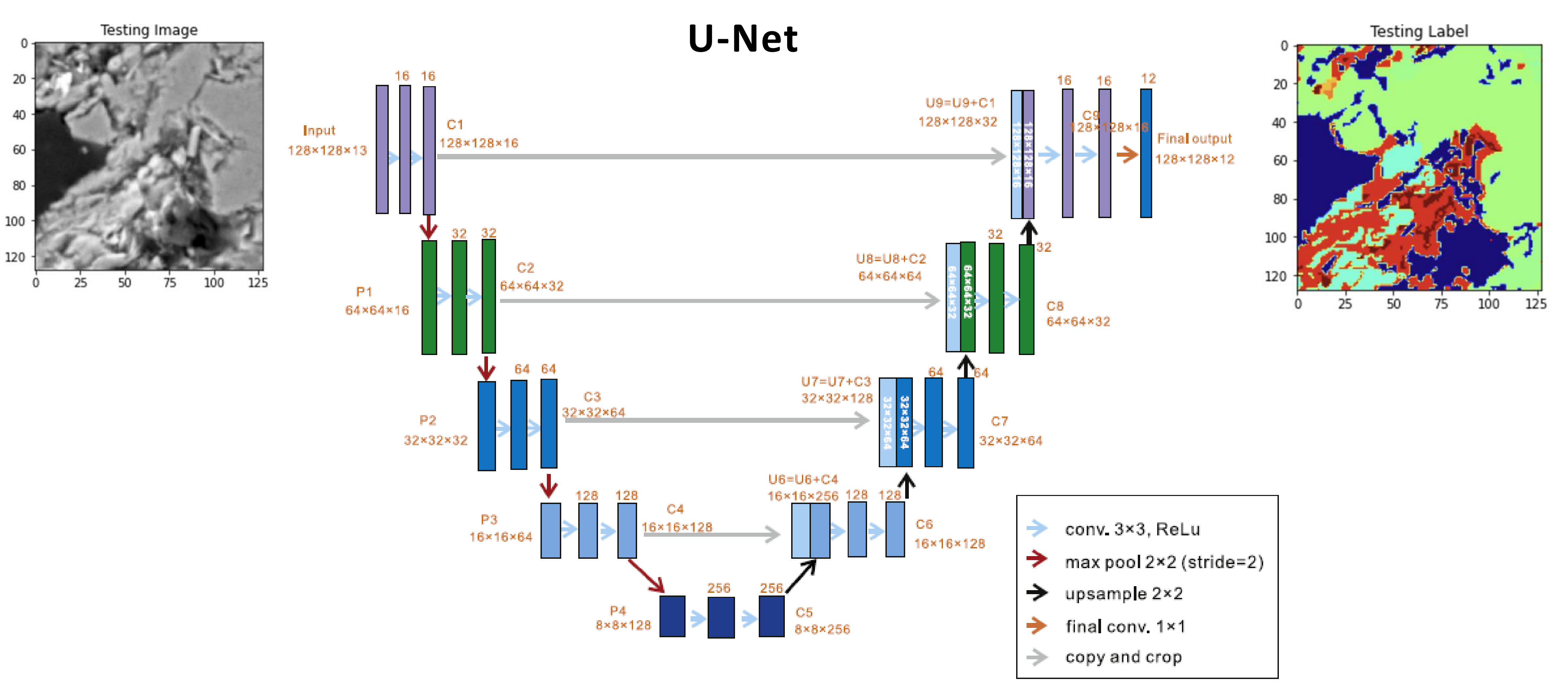




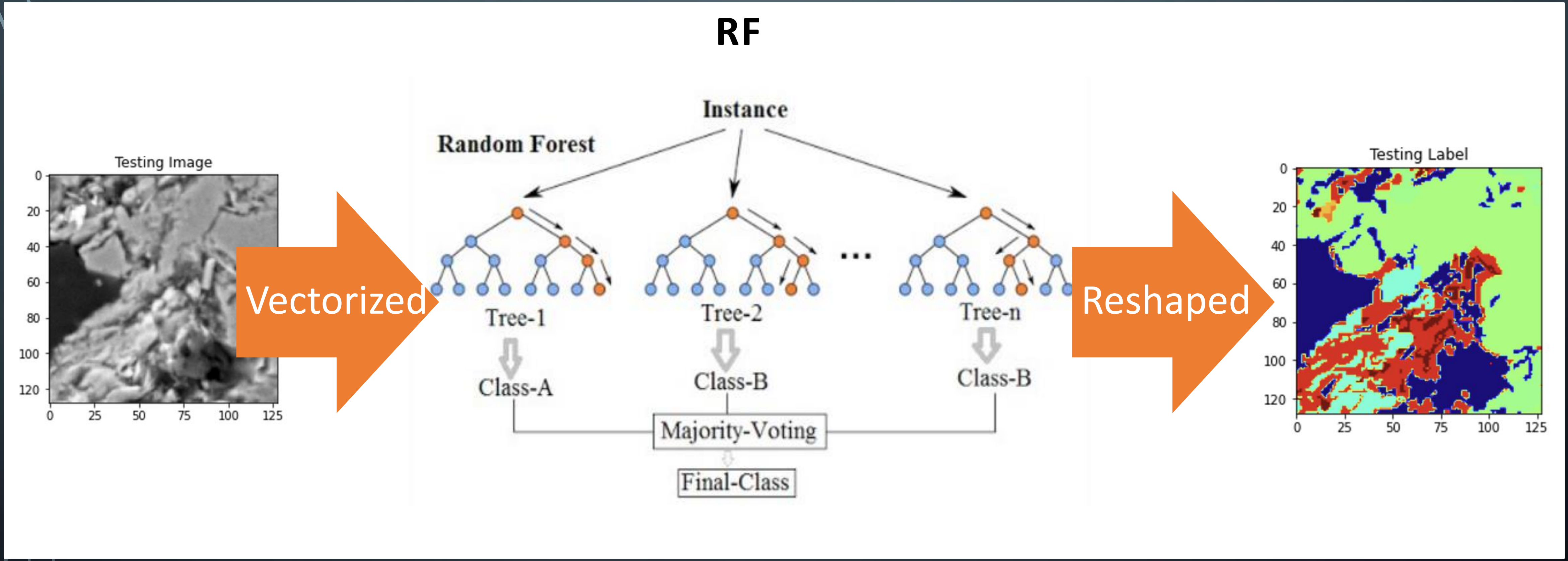
Objective

✓This study evaluates the performance of machine learning for mineral characterization and surface areas analysis of sandstone samples in various 2D image resolutions.

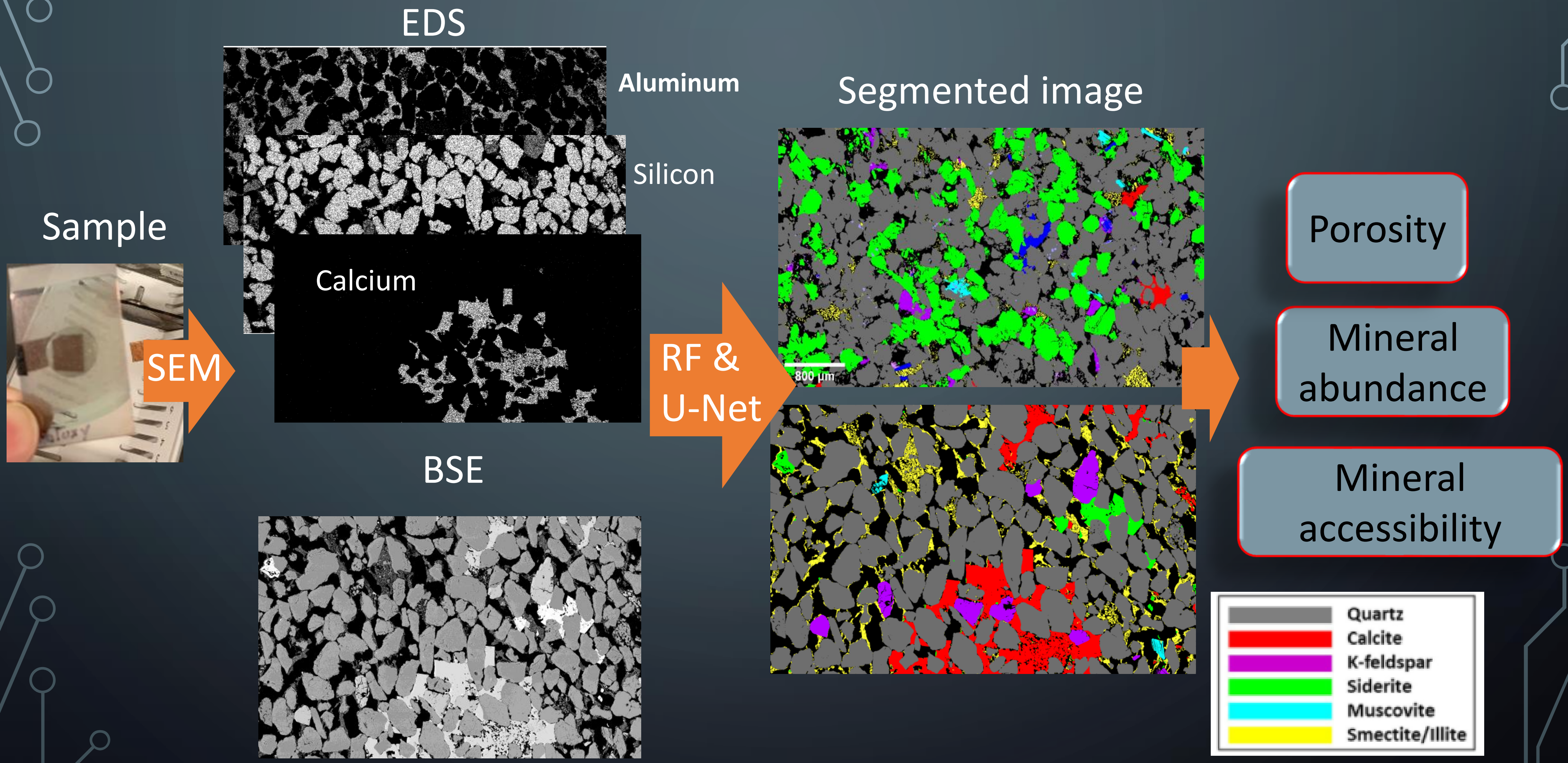
U-Net Deep Learning Method



Random Forest Machine Learning Method



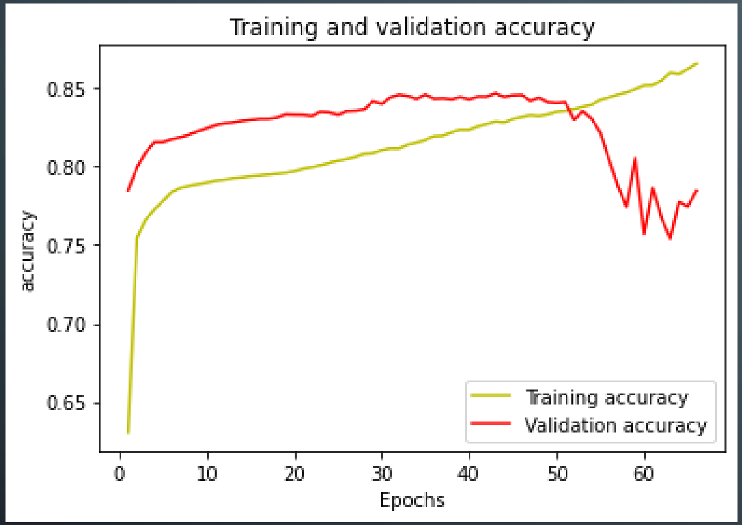
Workflow of The Study

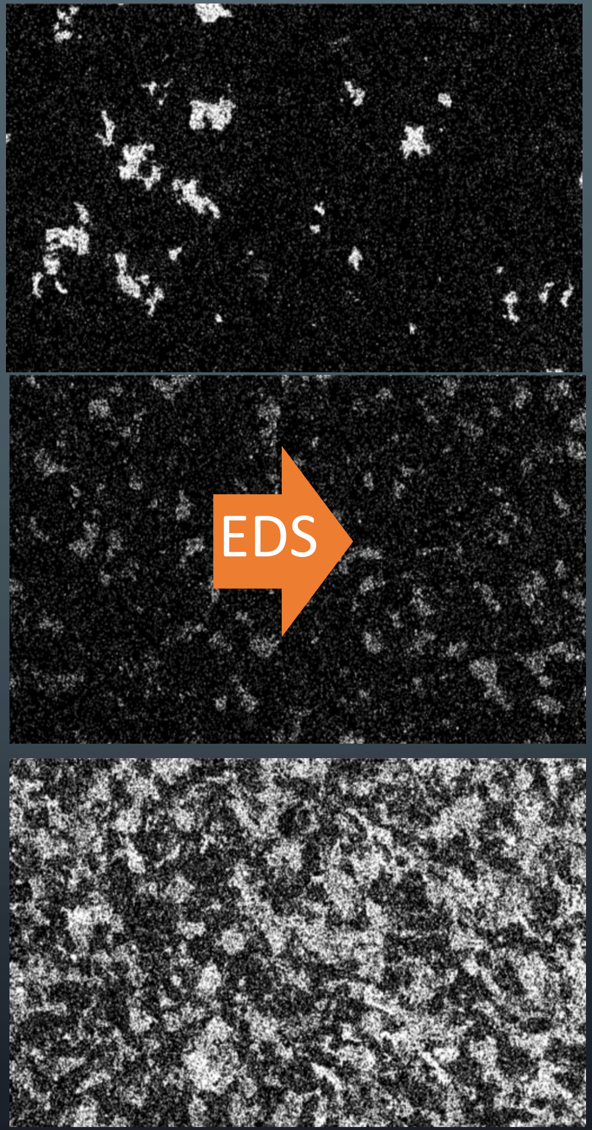


Results and Discussion

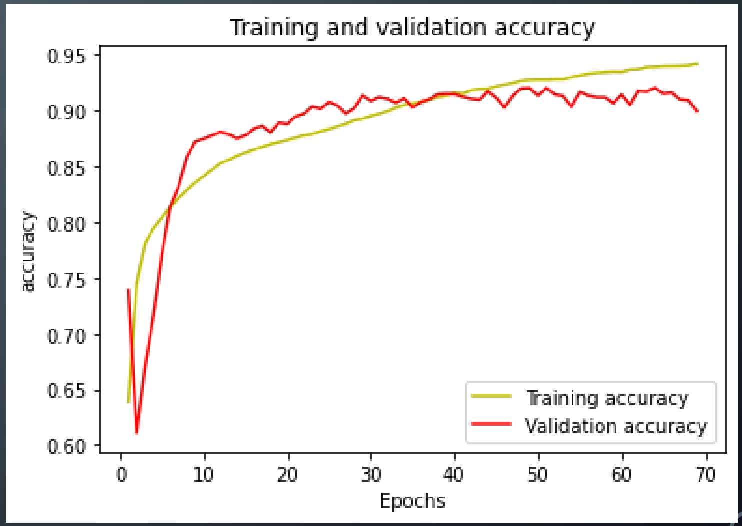
EDS elemental maps provided reliable features to segment different minerals and the model could recognize them.

BSE

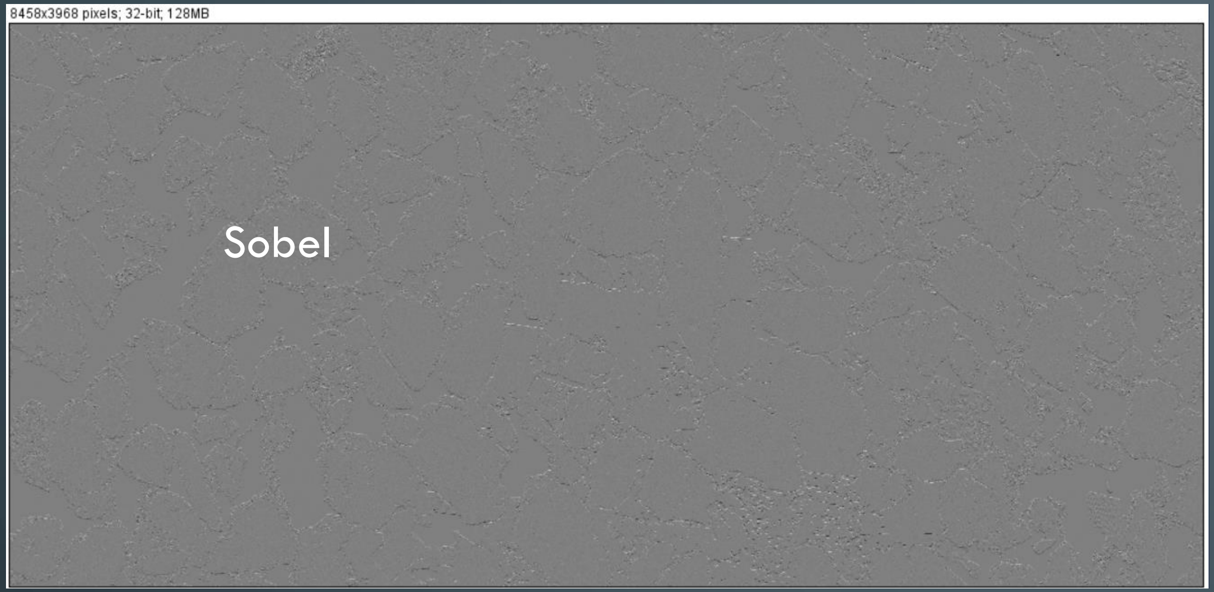


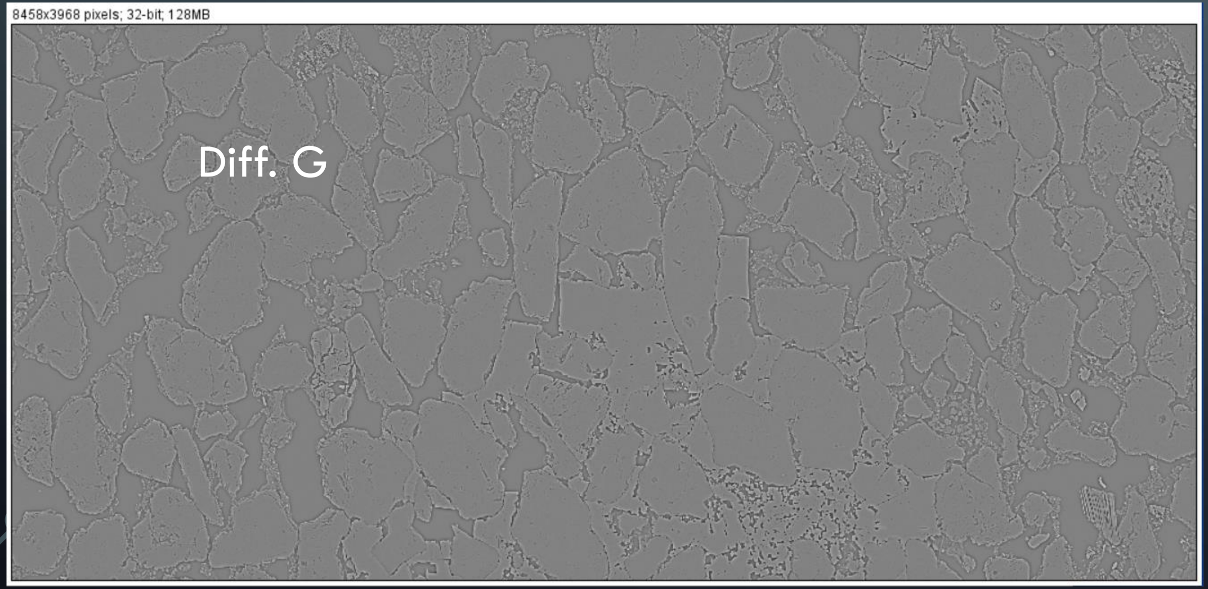


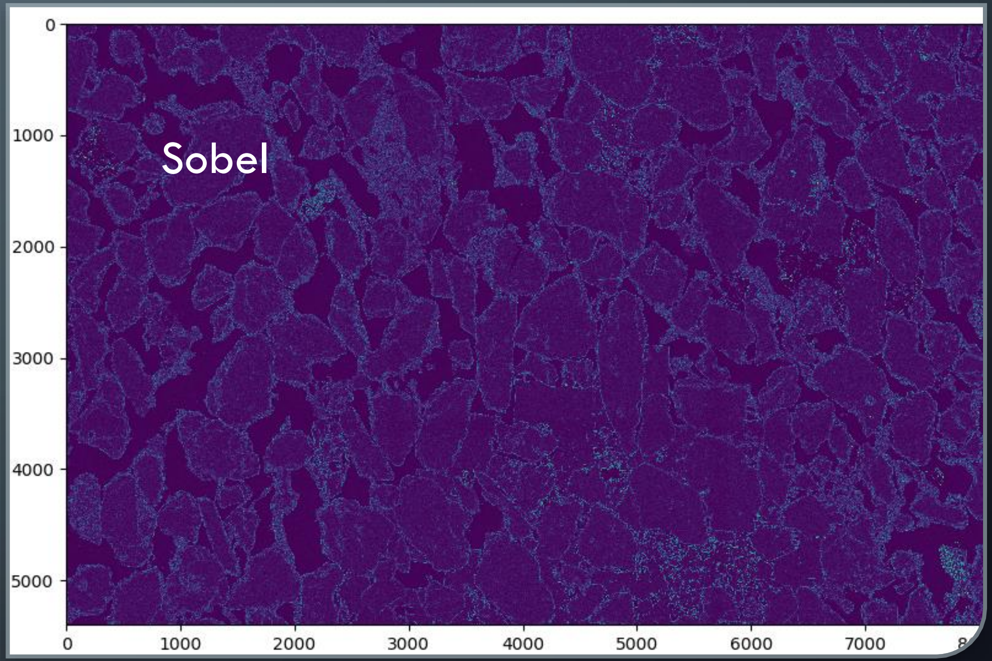
BSE & EDS



Filters Add More Features.

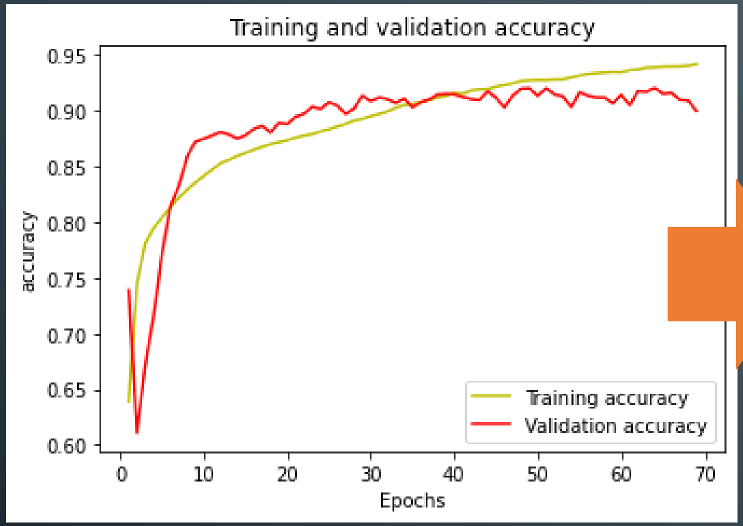




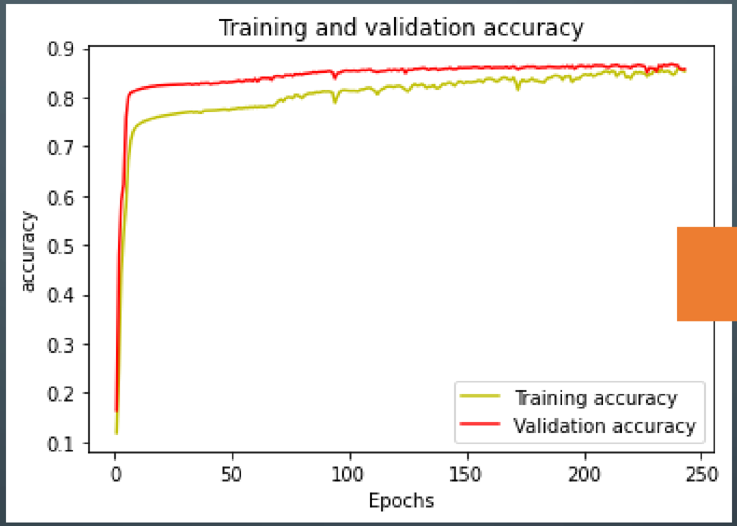


Results improved by considering both elemental and filter extracted features.

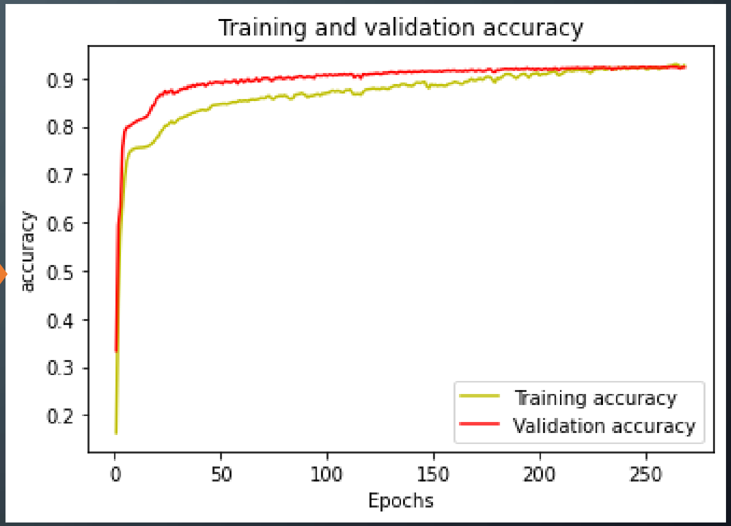
BSE & EDS



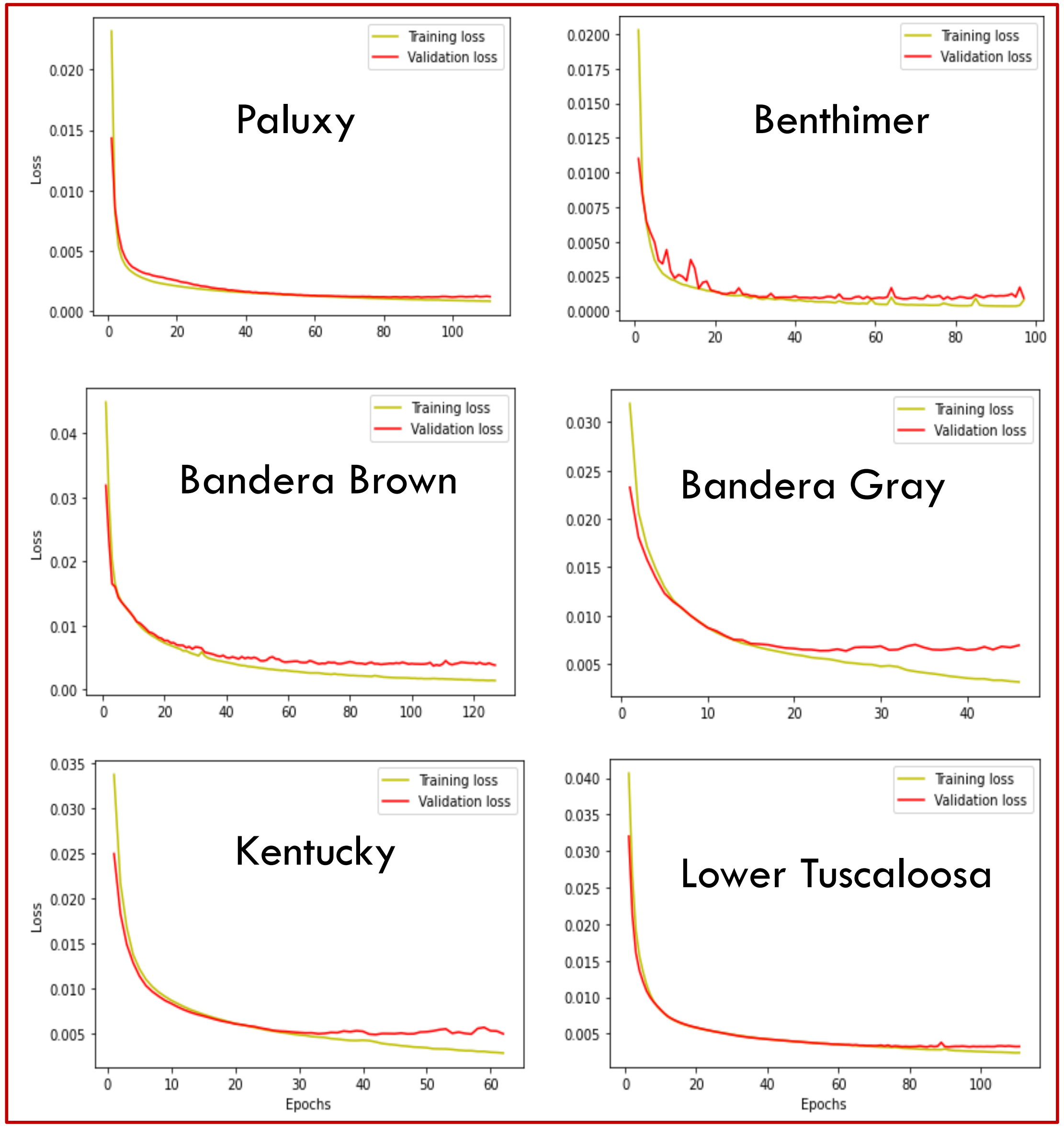
BSE & Filters

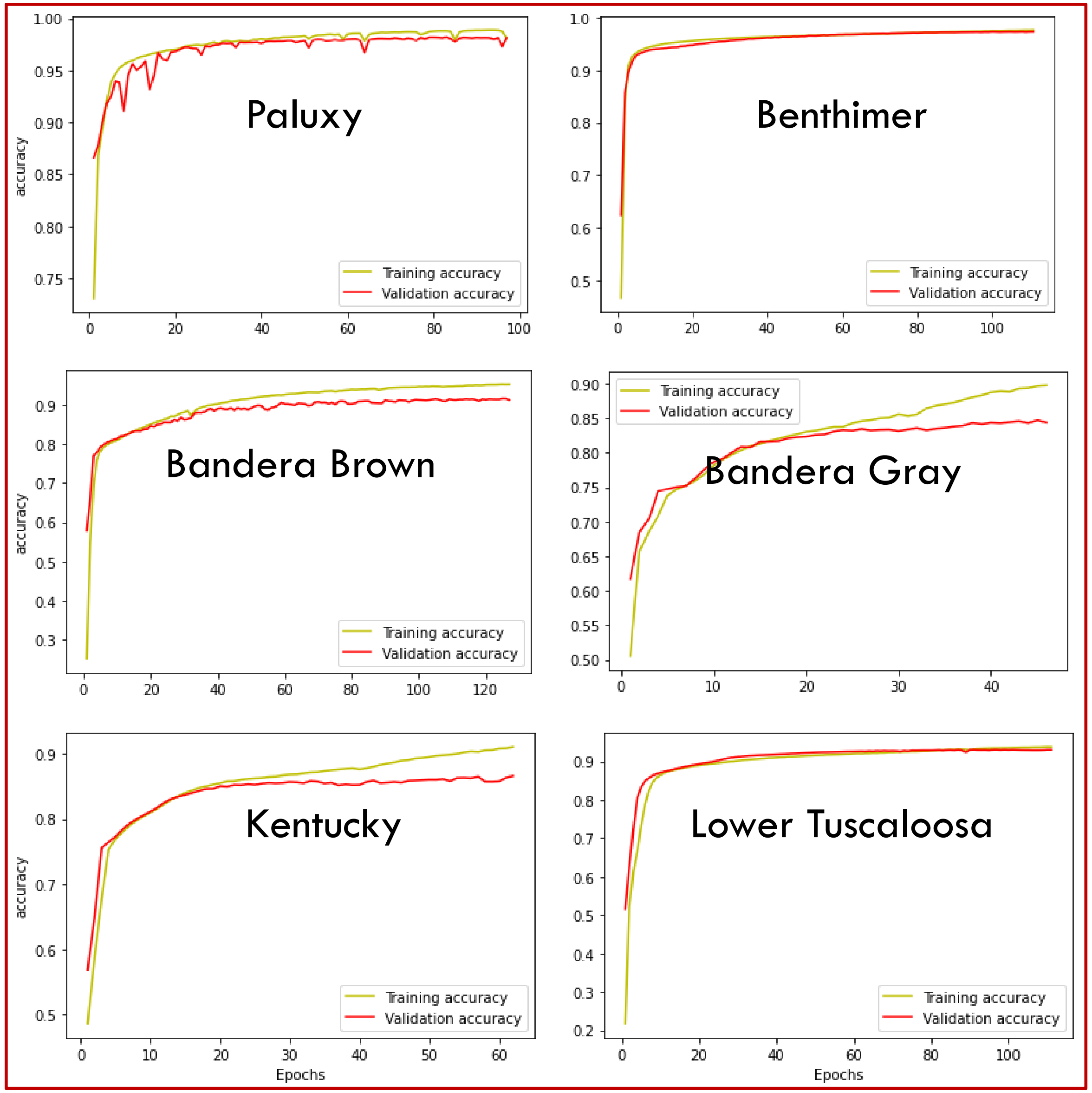


BSE & EDS & Filters



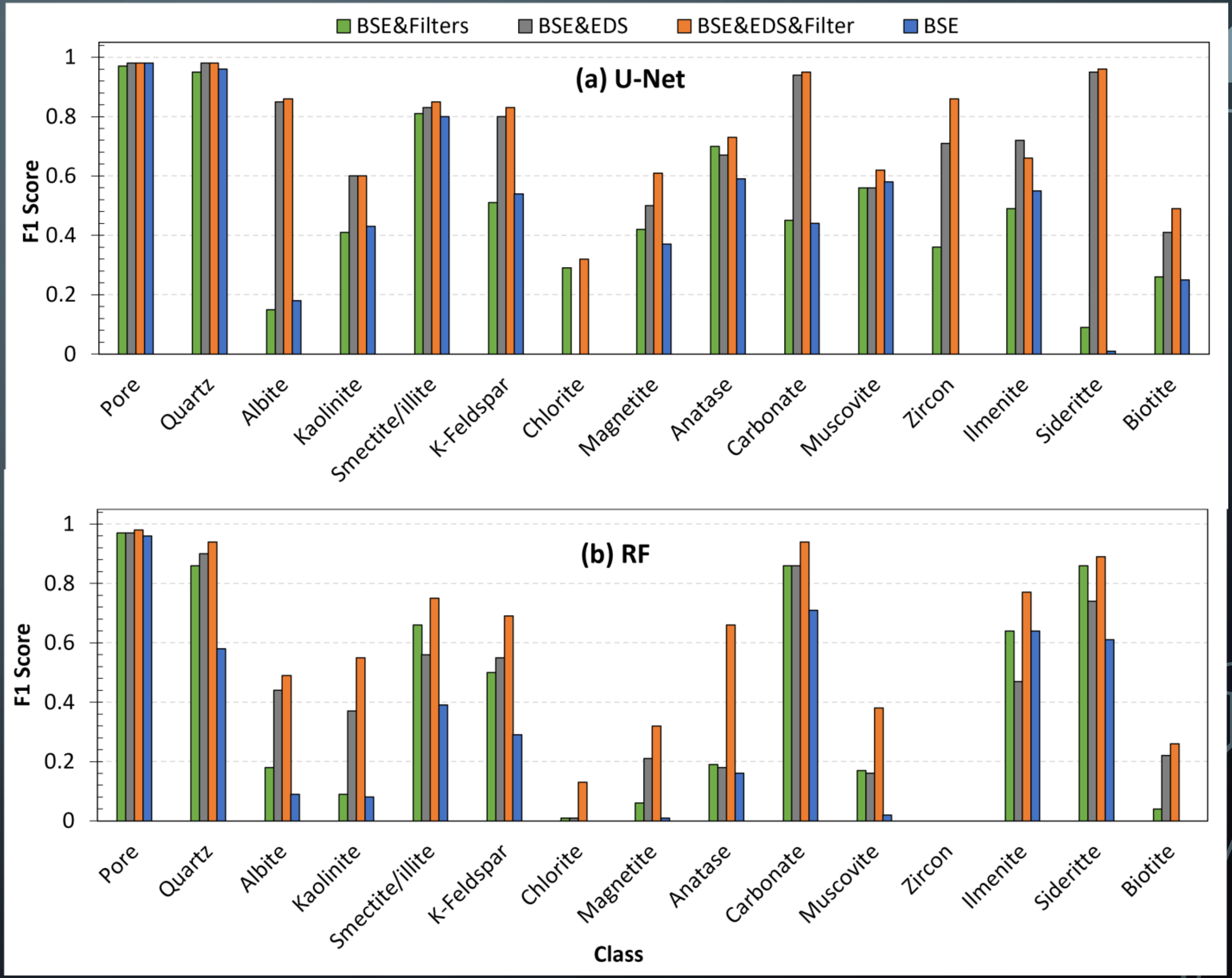
Convergence Loss and Accuracy Curves Along Iteration





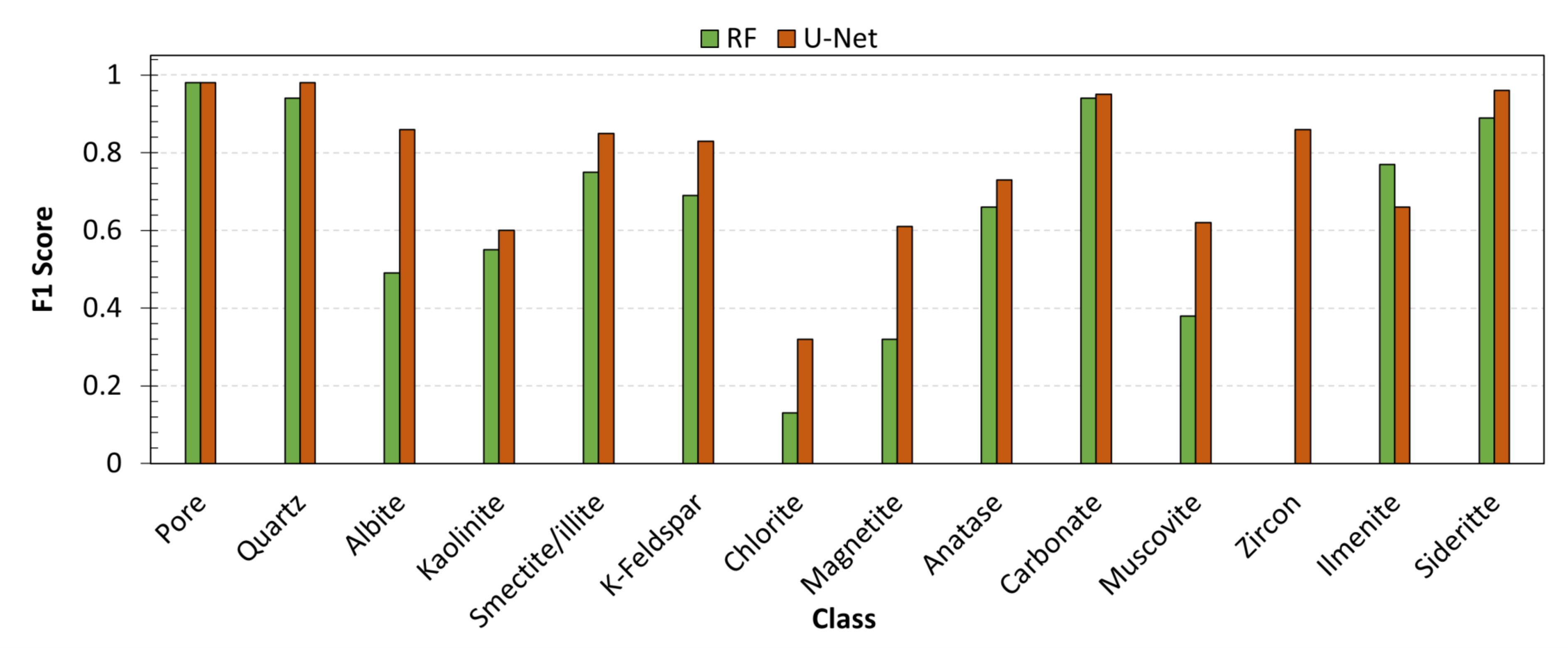
Performance of Models for Mineral Classification

Both methods had better performance when considering both EDS and filtered images.

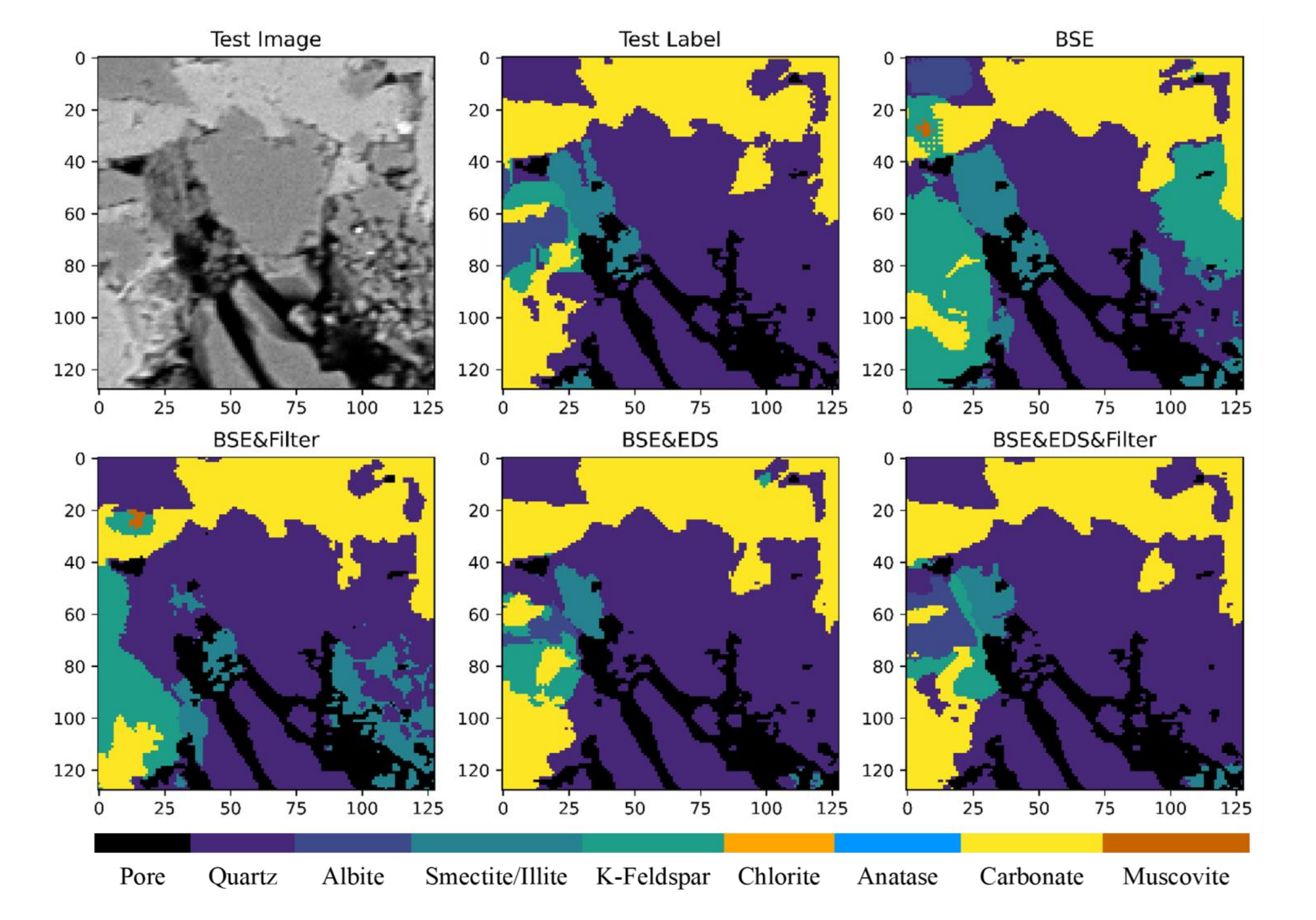


Comparison of RF and U-Net Performance

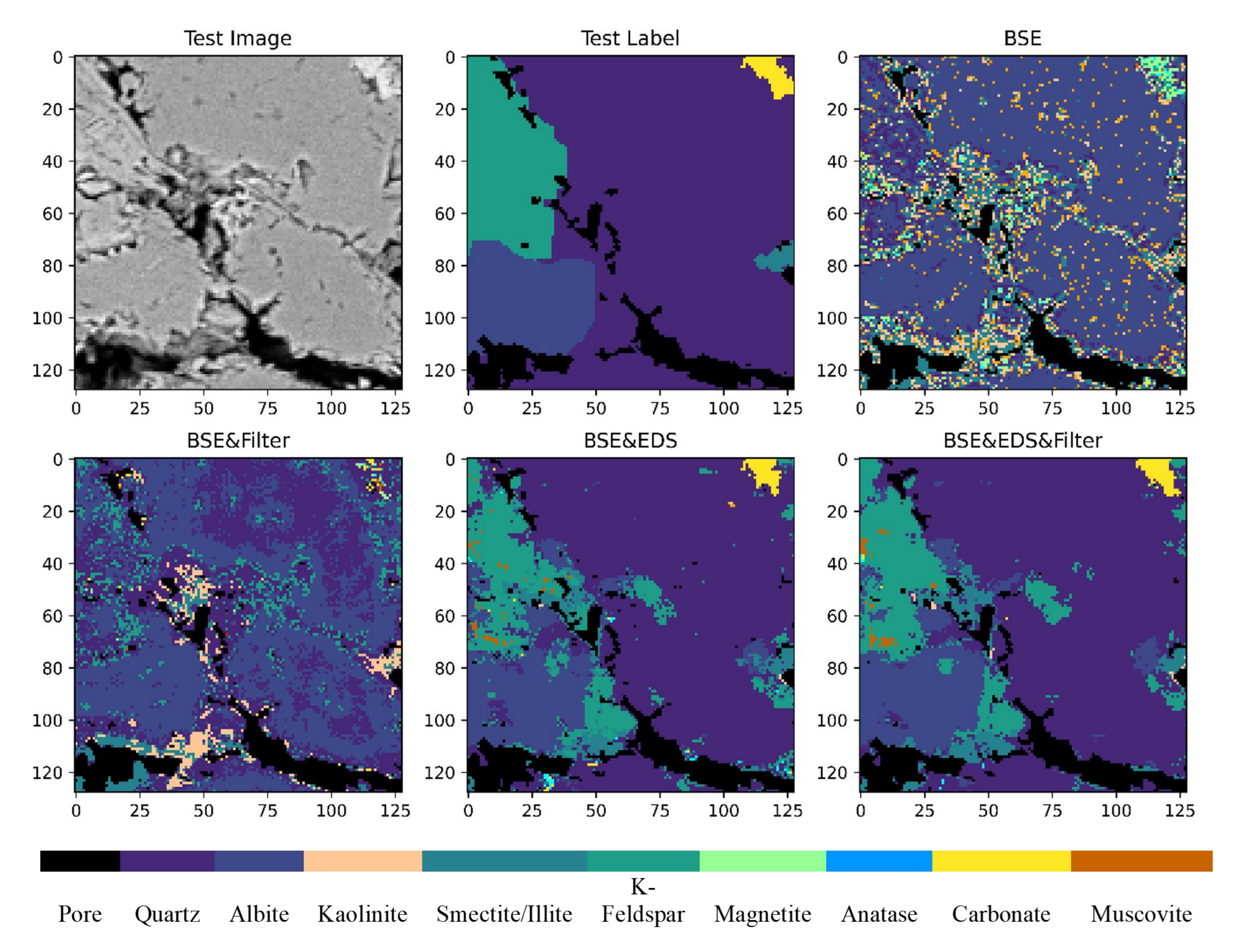
U-Net had better results for all minerals.



U-Net Predicted Results On Unseen Sample

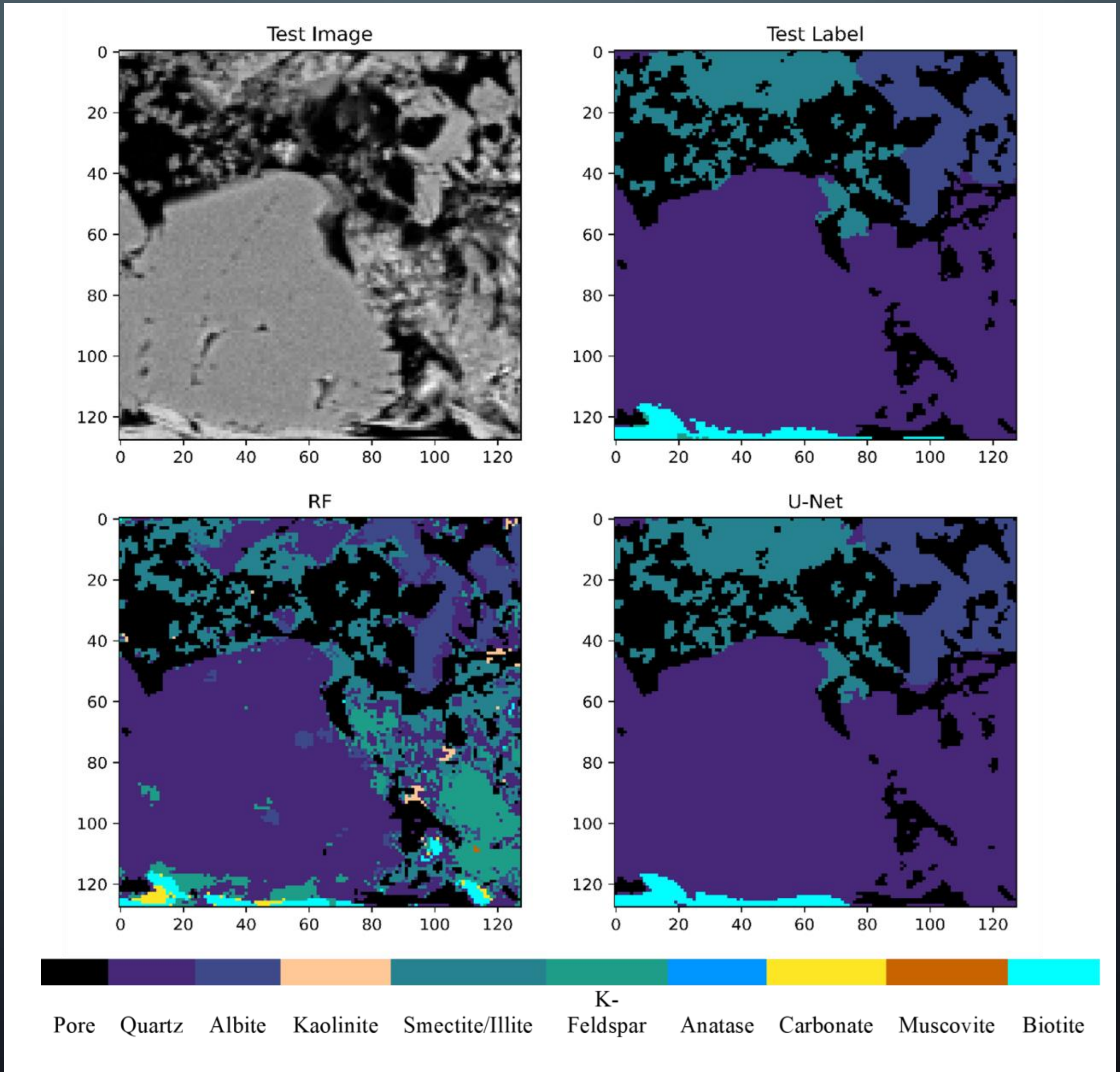


RF Predicted Results On Unseen Sample



Predicted Results On Unseen Sample

U-Net had better performance with less noise.



Predicted Accessibility and Abundance.

Mineral	Chemical formula	Method	Abundance (%)	Accessibility (%)
Quartz	SiO_2	ground truth	76.83	57.61
		RF	72.62	44.79
		U-Net	77.72	55.86
Kaolinite	$Al_2Si_2O_5(OH)_4$	ground truth	0.39	4.85
		RF	0.64	7.18
		U-Net	0.27	3.25
Carbonate	$CaCO_3/MgCO_3{\cdot}CaCO_3$	ground truth	8.47	3.45
		RF	8.35	2.96
		U-Net	6.76	2.46
K-feldspar	$KAlSi_3O_8$	ground truth	3.86	3.30
		RF	4.12	2.07
		U-Net	4.82	3.98

Conclusion

- Both RF and U-Net models had good performance for predicting quartz (**majority**) abundance and accessibility.
- U-Net achieved a better performance in predicting minority classes such as chlorite and carbonate.
- Similar performance was observed in all models, showing the robustness of the proposed framework.
- The obtained parameters can be utilized to inform reactive transport simulations.

Acknowledgments & Reference

- This material is based upon work supported by the National Science Foundation under Grant No: 1847243

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THANK YOU

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