

Seeing Minerals Clearly

Learning Dimension Reductions on Spectral Reflectance Libraries for Efficient In Situ Multispectral Image Acquisition and Analysis

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and the PanCam Science Team

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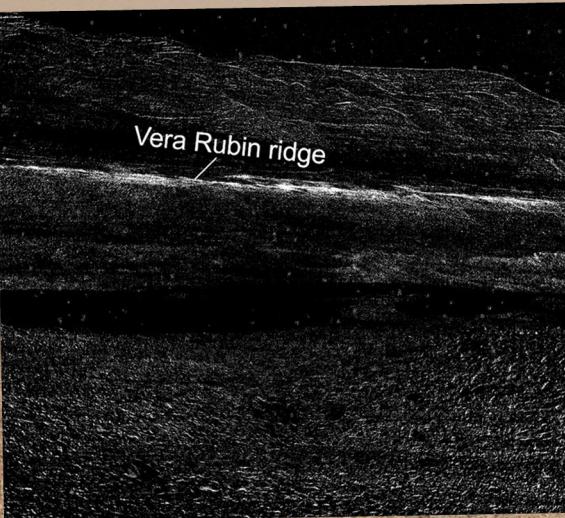
NASA/JPL/ASU/MSSS/Mastcam

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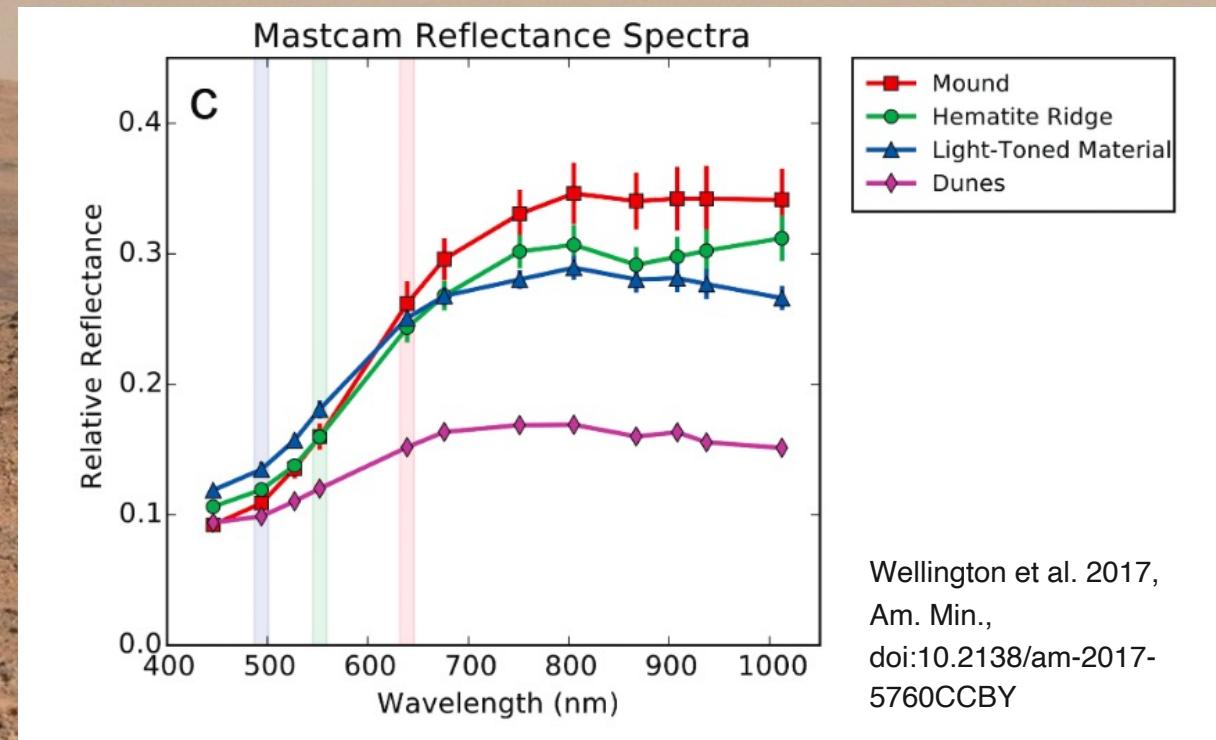
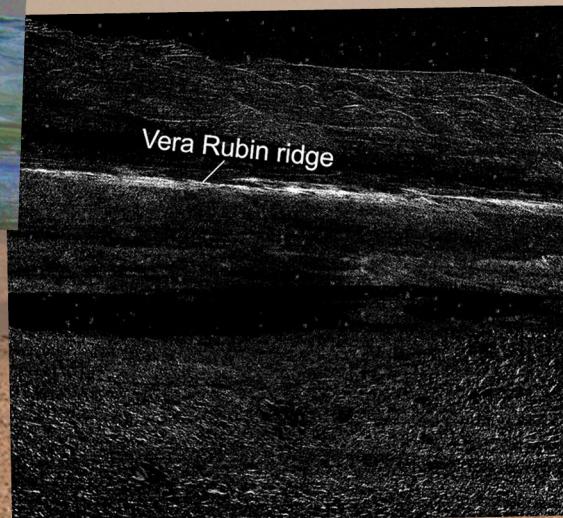
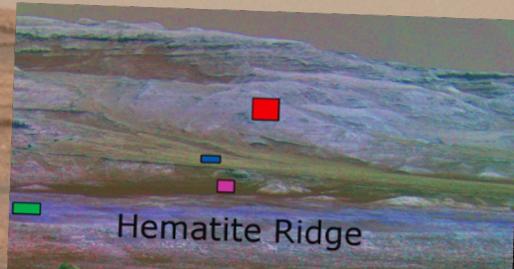
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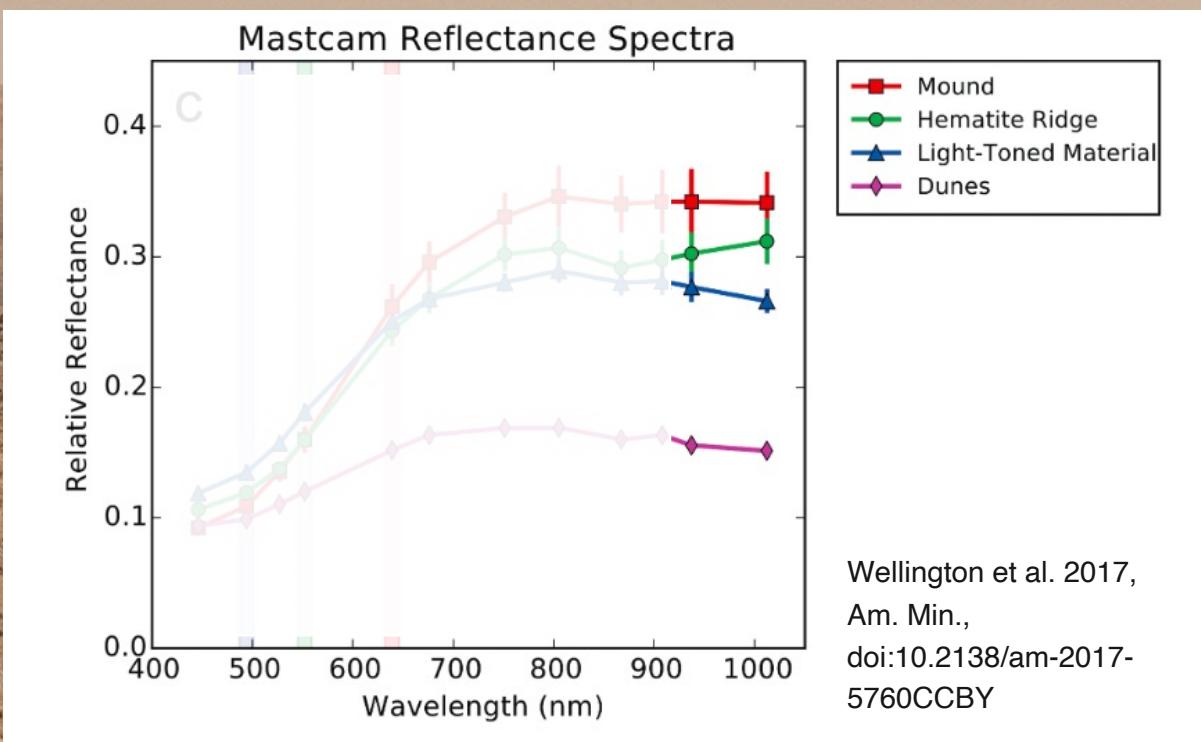
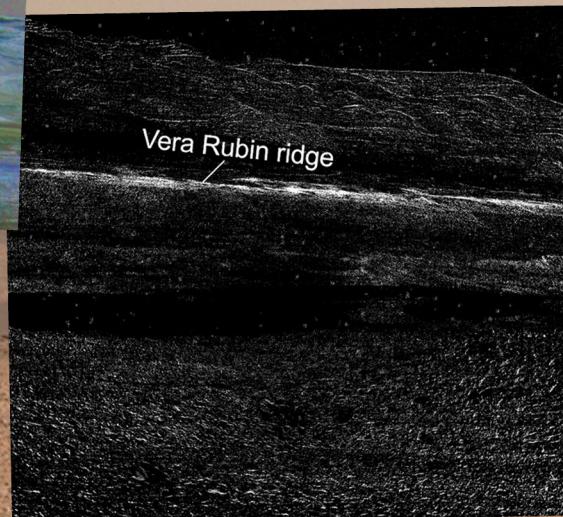
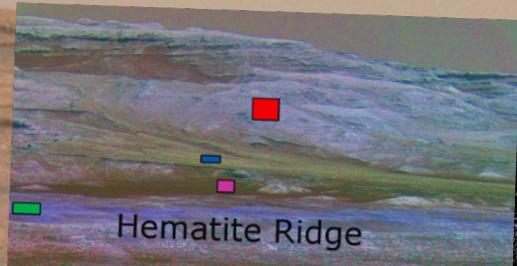
Wellington et al. 2017, Am. Min.,
doi:10.2138/am-2017-5760CCBY

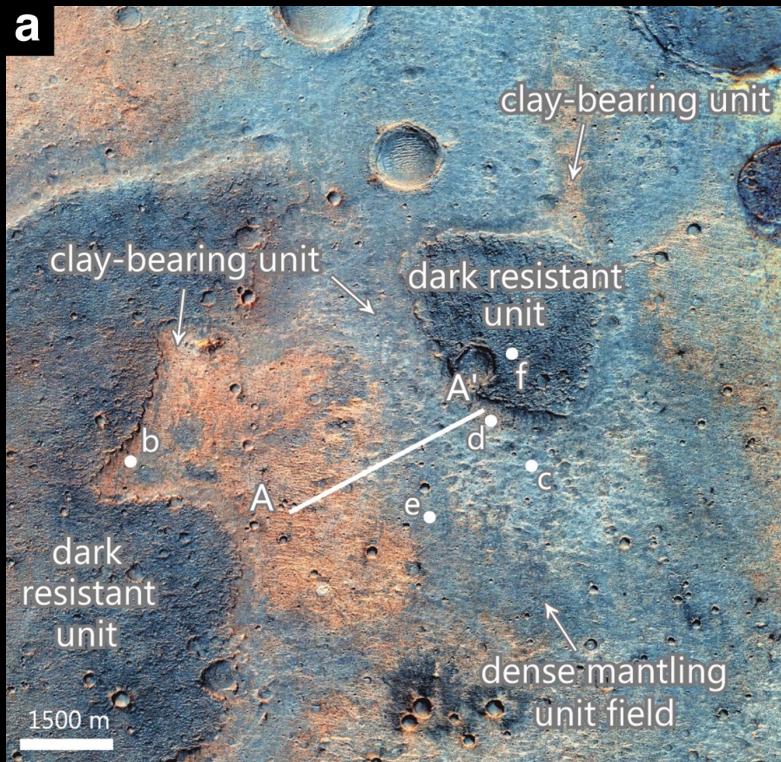
Fraeman et al. 2020, JGR Planets,
doi:10.1029/2019JE006294



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Fraeman et al. 2020, JGR Planets,
doi:10.1029/2019JE006294





Quantin—Nataf et al. 2021, Astrobiology,
Oxia Planum: The Landing Site for the
ExoMars “Rosalind Franklin” Rover Mission:
Geological Context and Prelanding
Interpretation
DOI: 10.1089/ast.2019.2191

Case Study

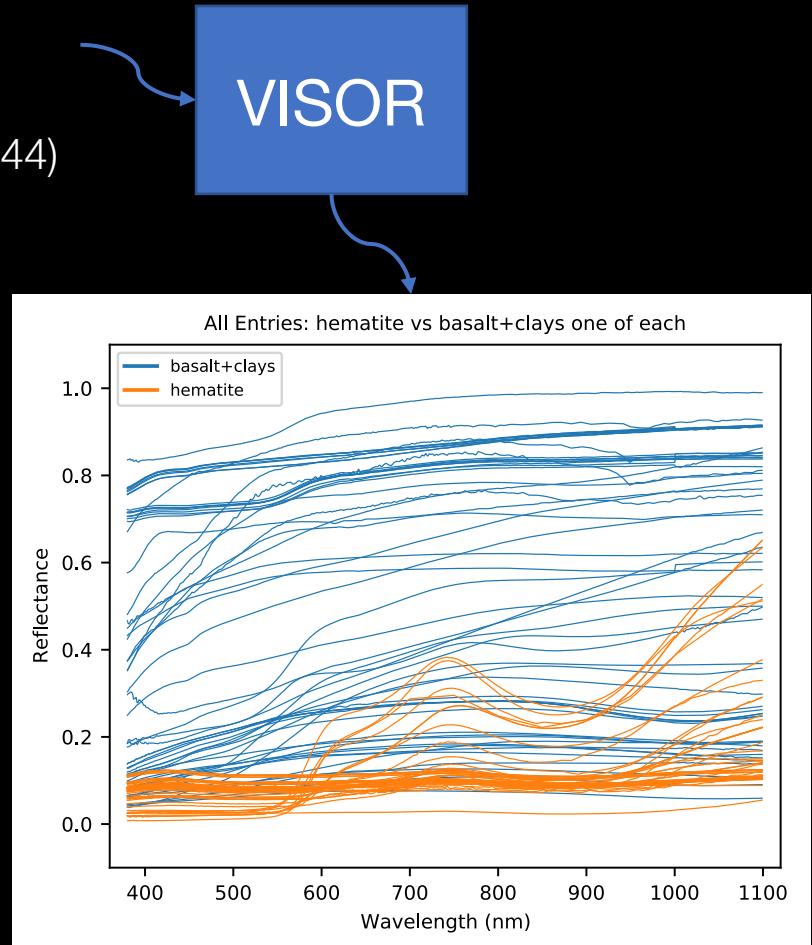
target: Hematite

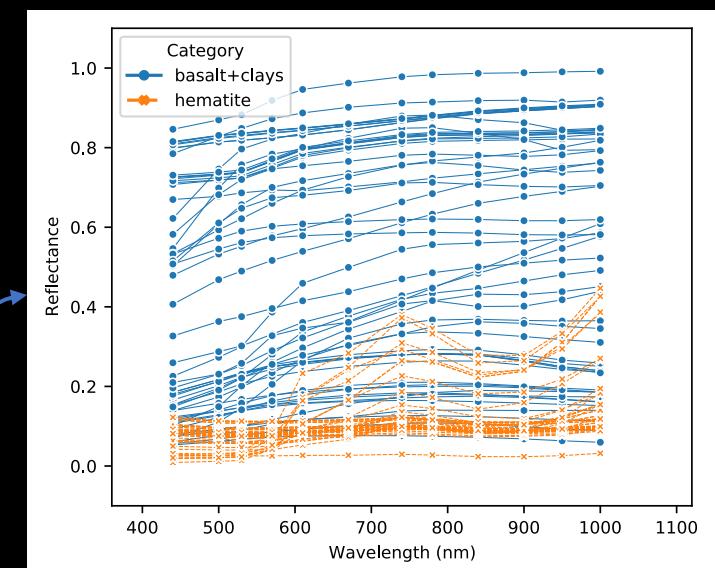
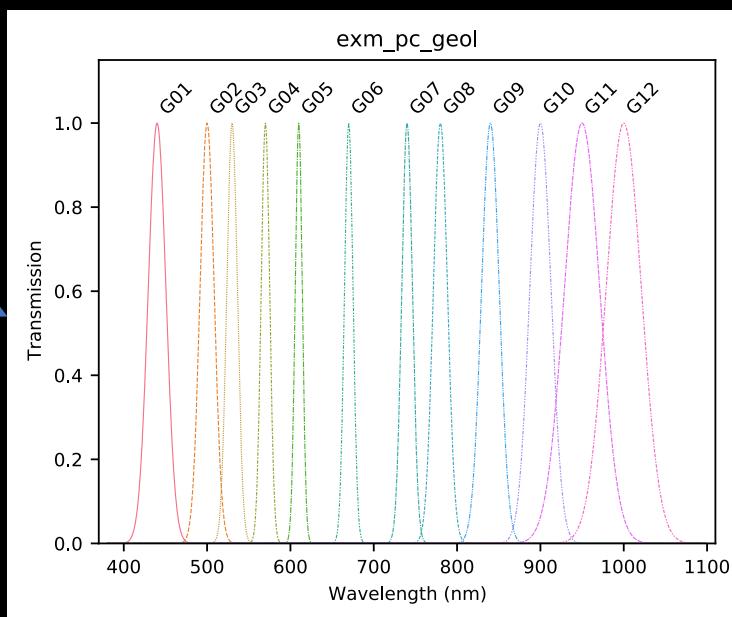
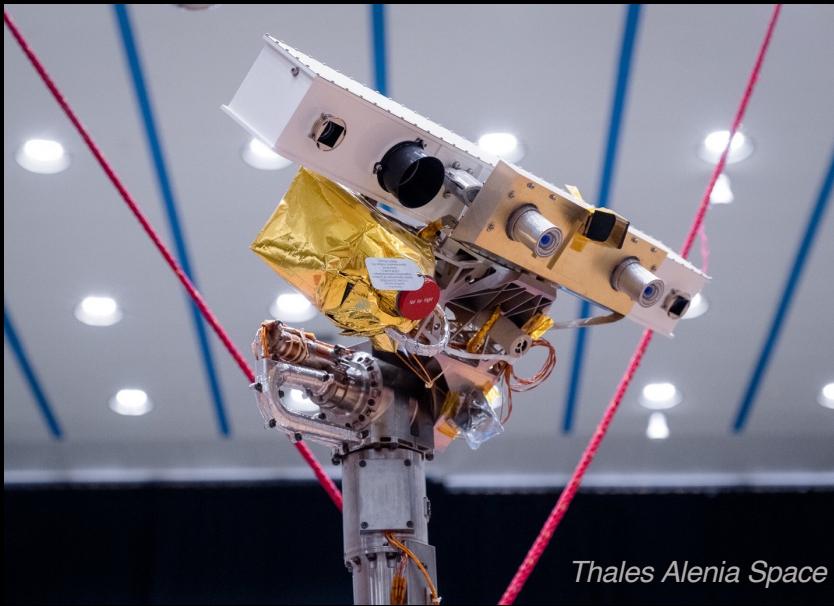
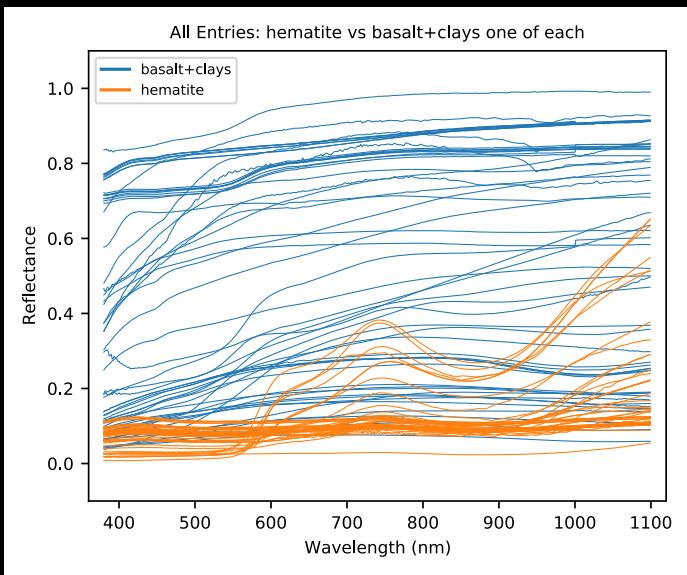
- hematite ($\times 83$)

background: Clays & Basalts

- vermiculite ($\times 26$)
- saponite ($\times 102$)
- montmorillonite ($\times 144$)
- basalt ($\times 71$)
- basaltic soil ($\times 10$)

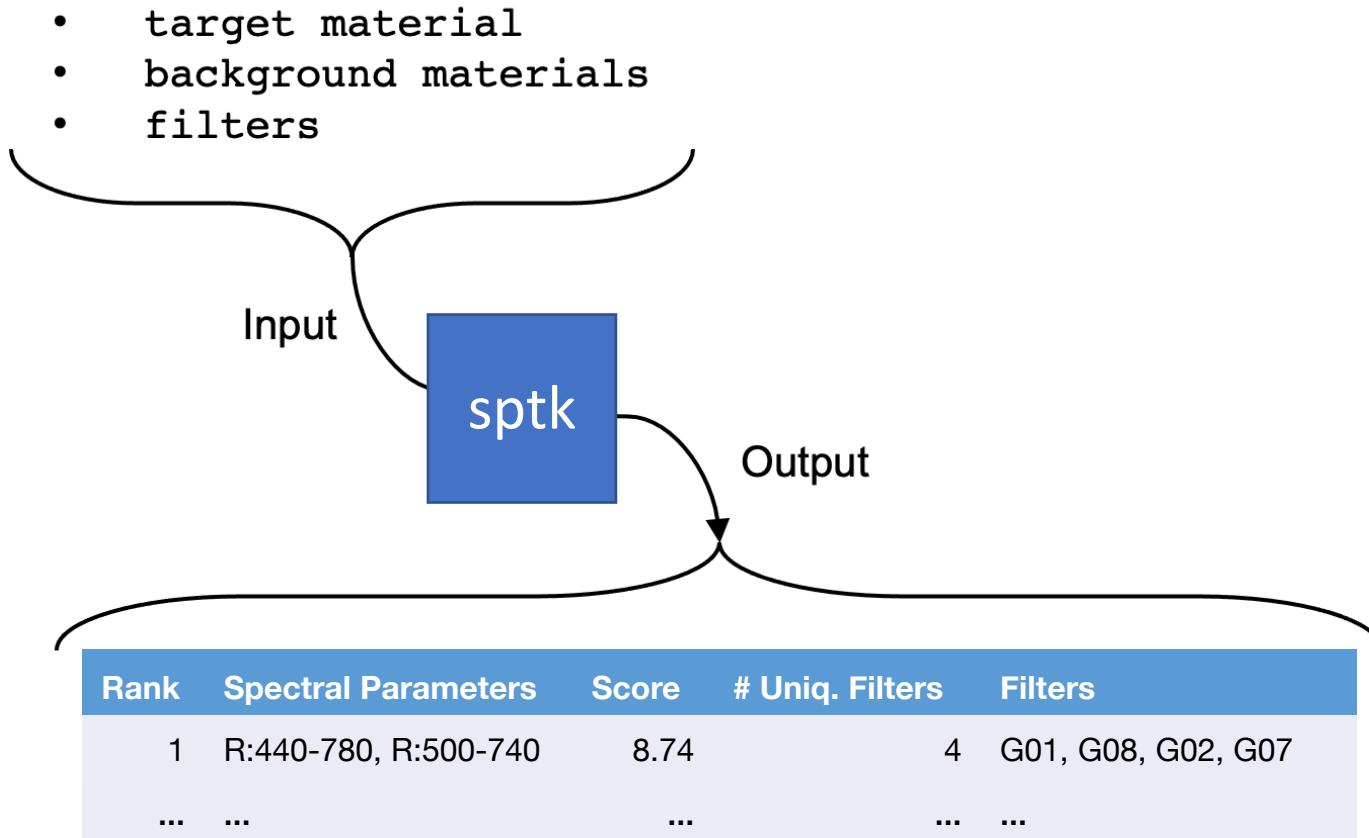
Western Washington University
Visible-Infrared Spectral Browser
<https://westernreflectancelab.com/visor/>





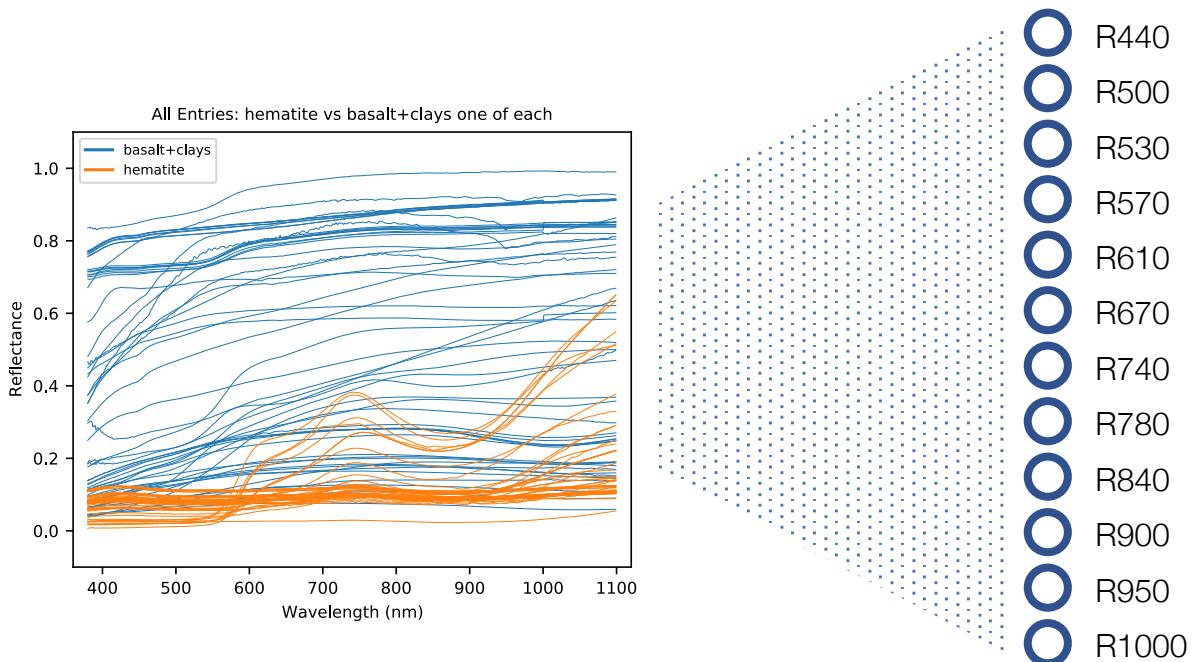
sptk: the Spectral Parameters Toolkit

A python library for exploring multispectral sampling



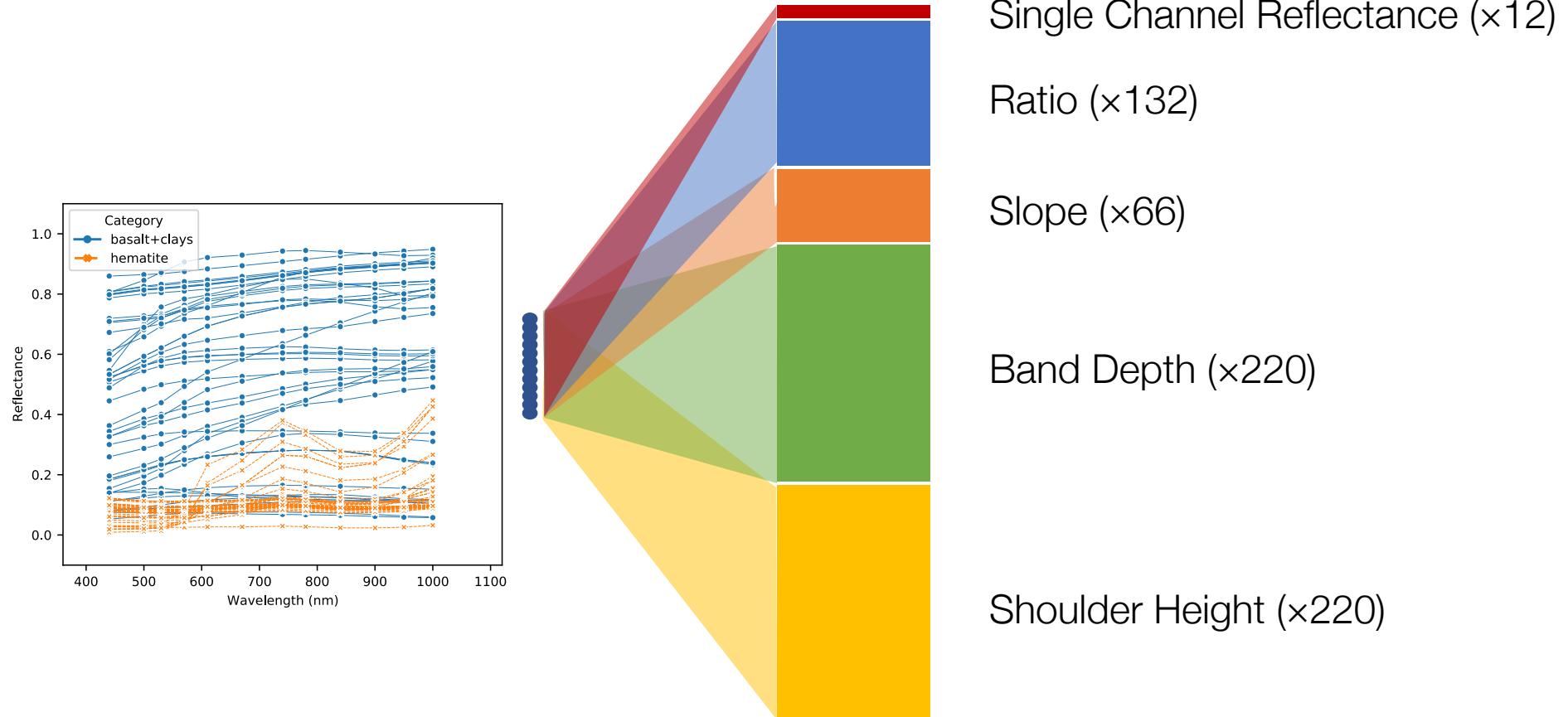
sptk: the Spectral Parameters Toolkit

Pipeline Overview



sptk: the Spectral Parameters Toolkit

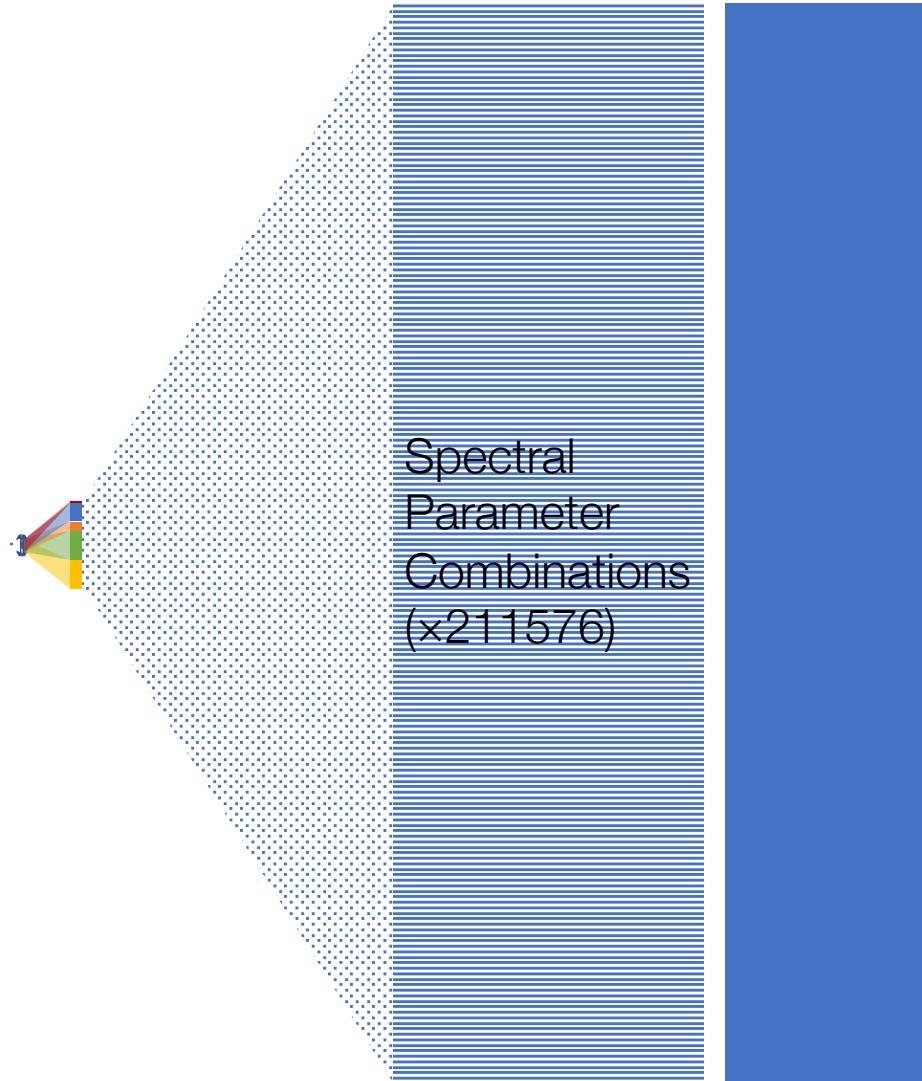
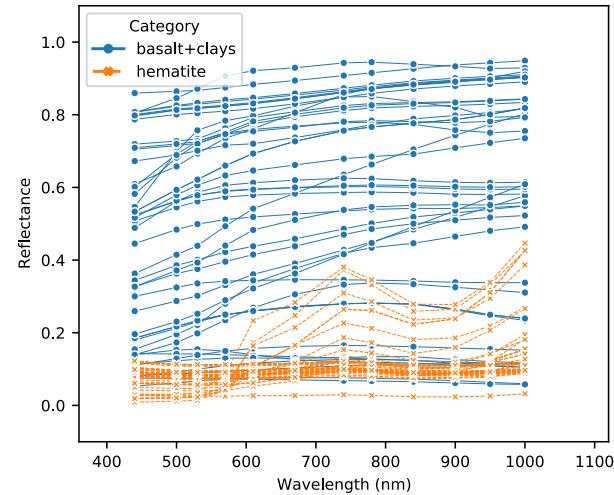
Pipeline Overview



sptk: the Spectral Parameters Toolkit

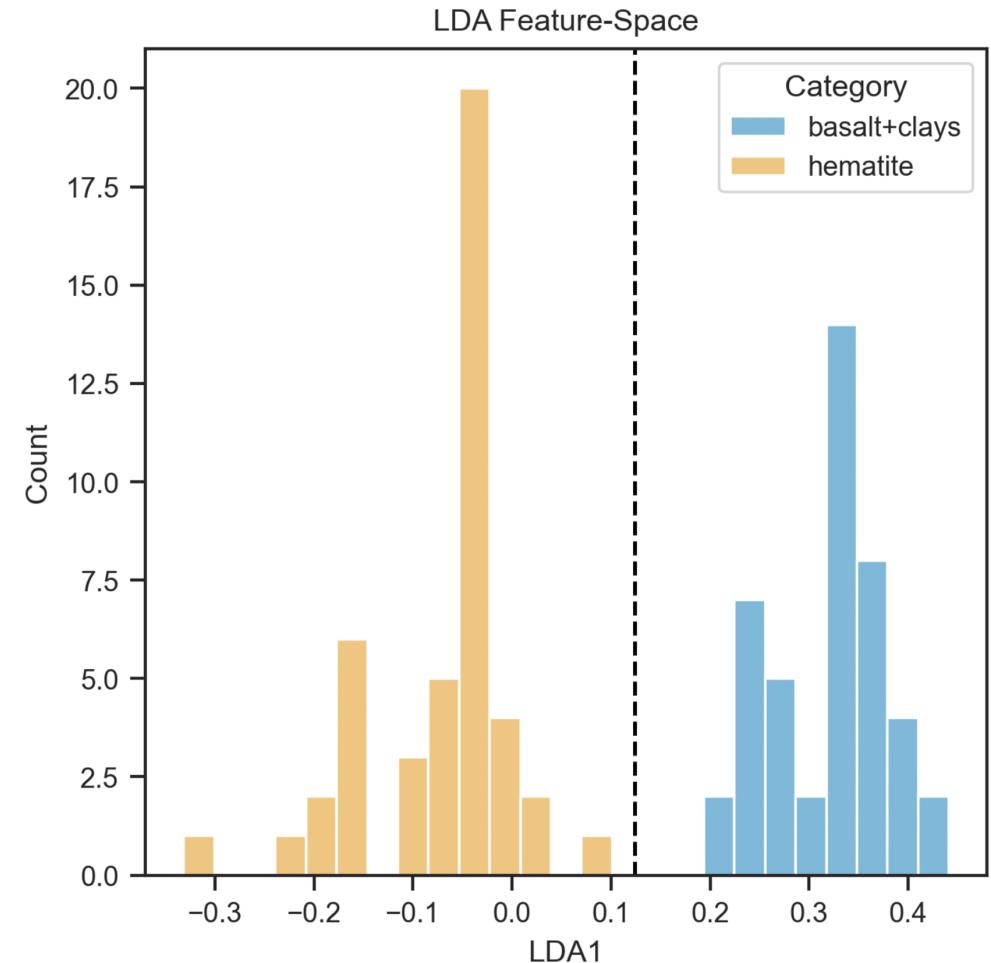
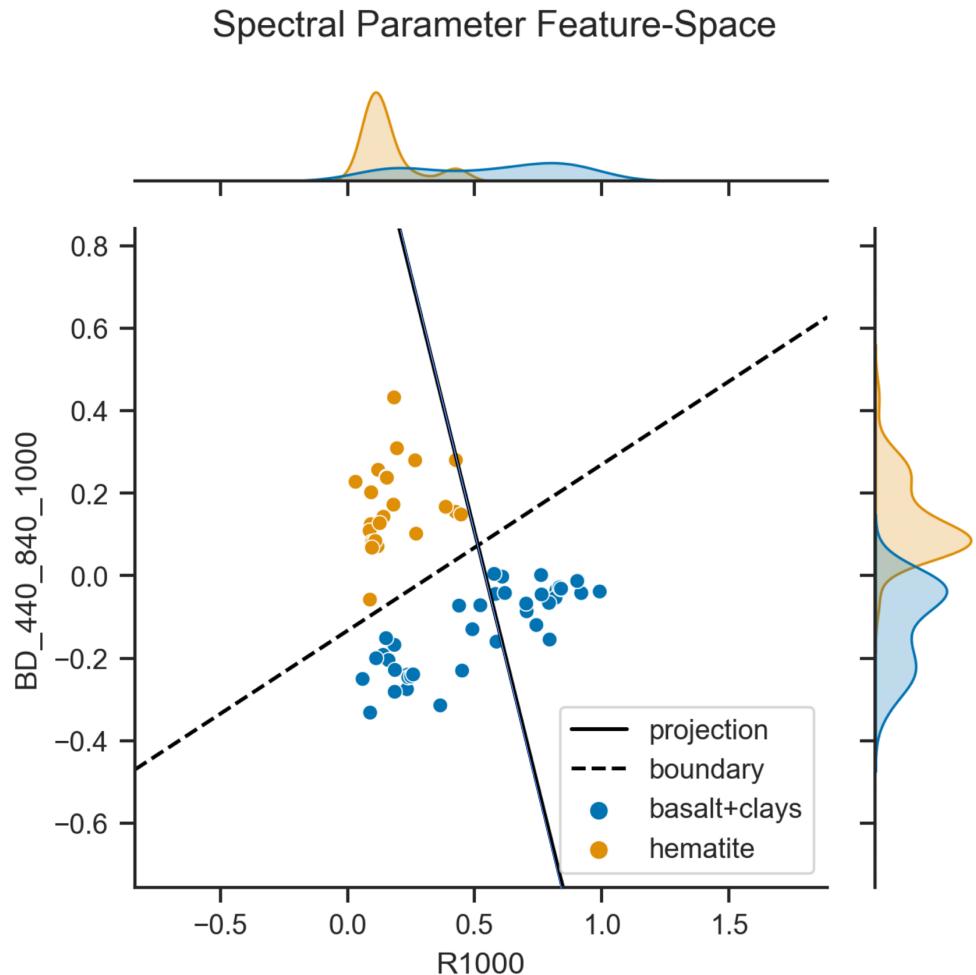
Pipeline Overview

Compute
LDA



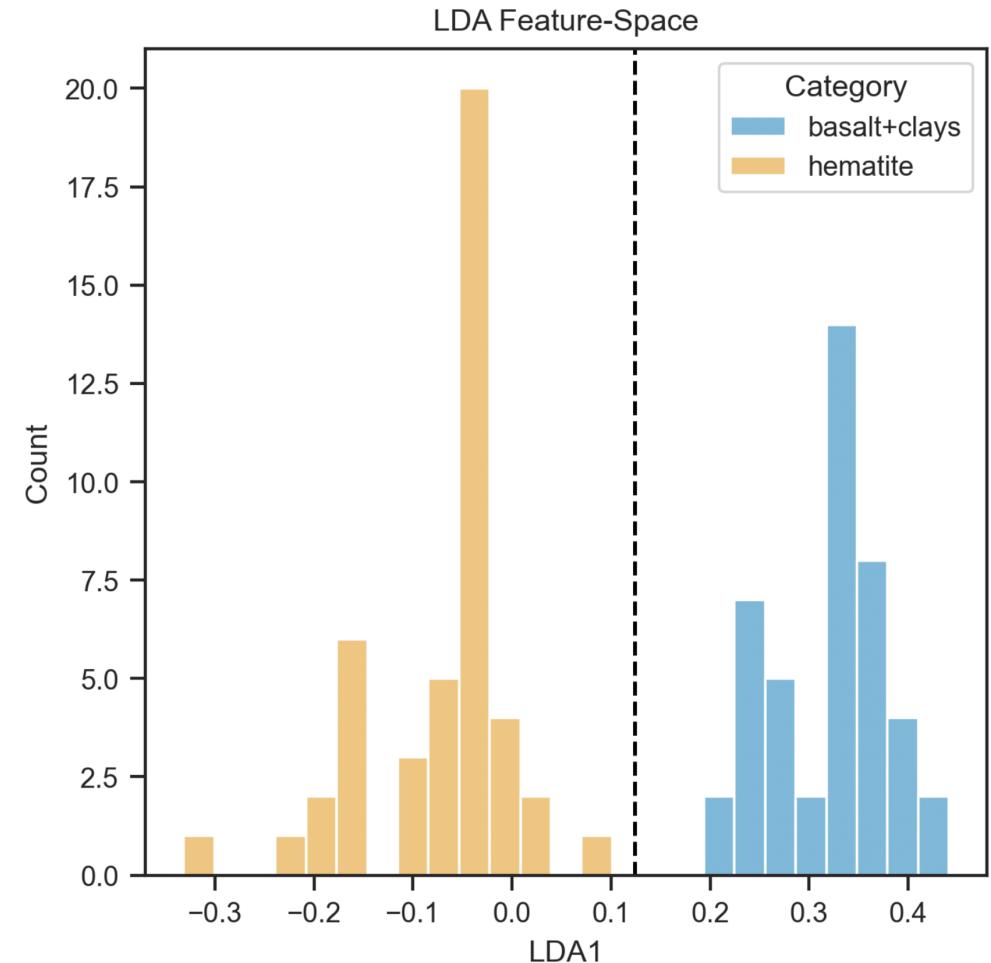
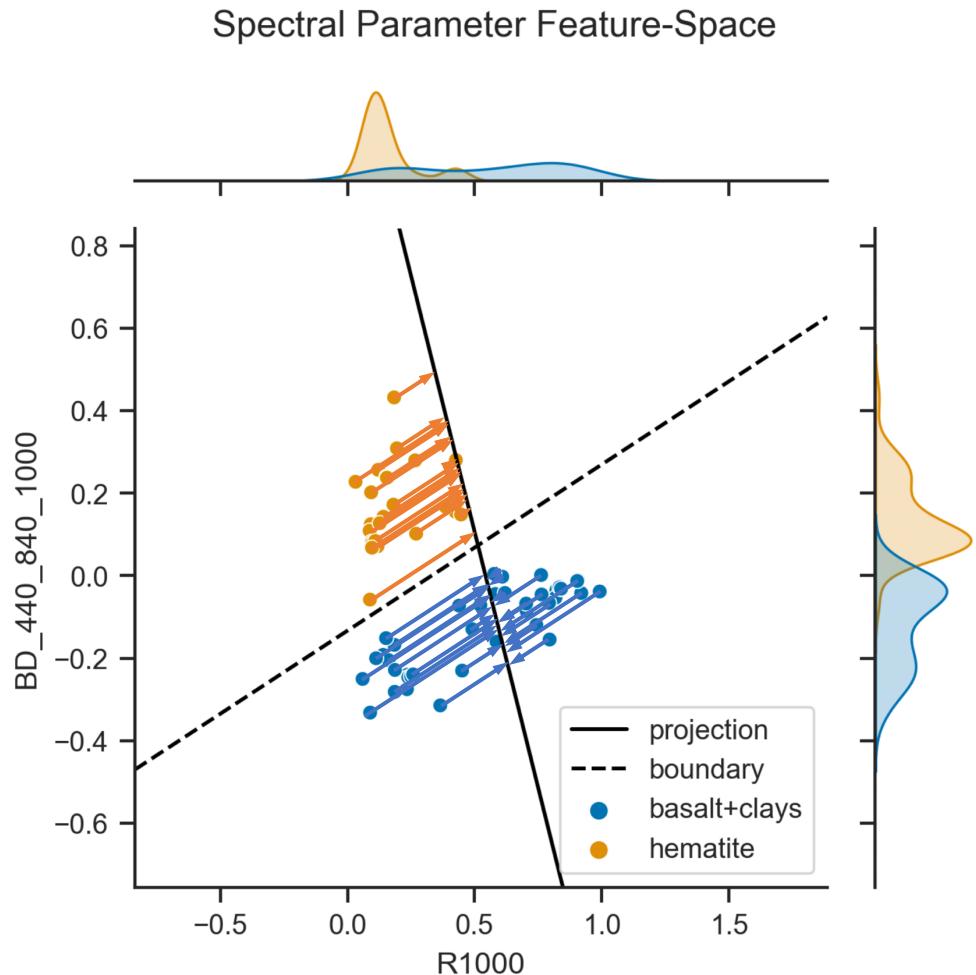
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Linear Discriminant Analysis



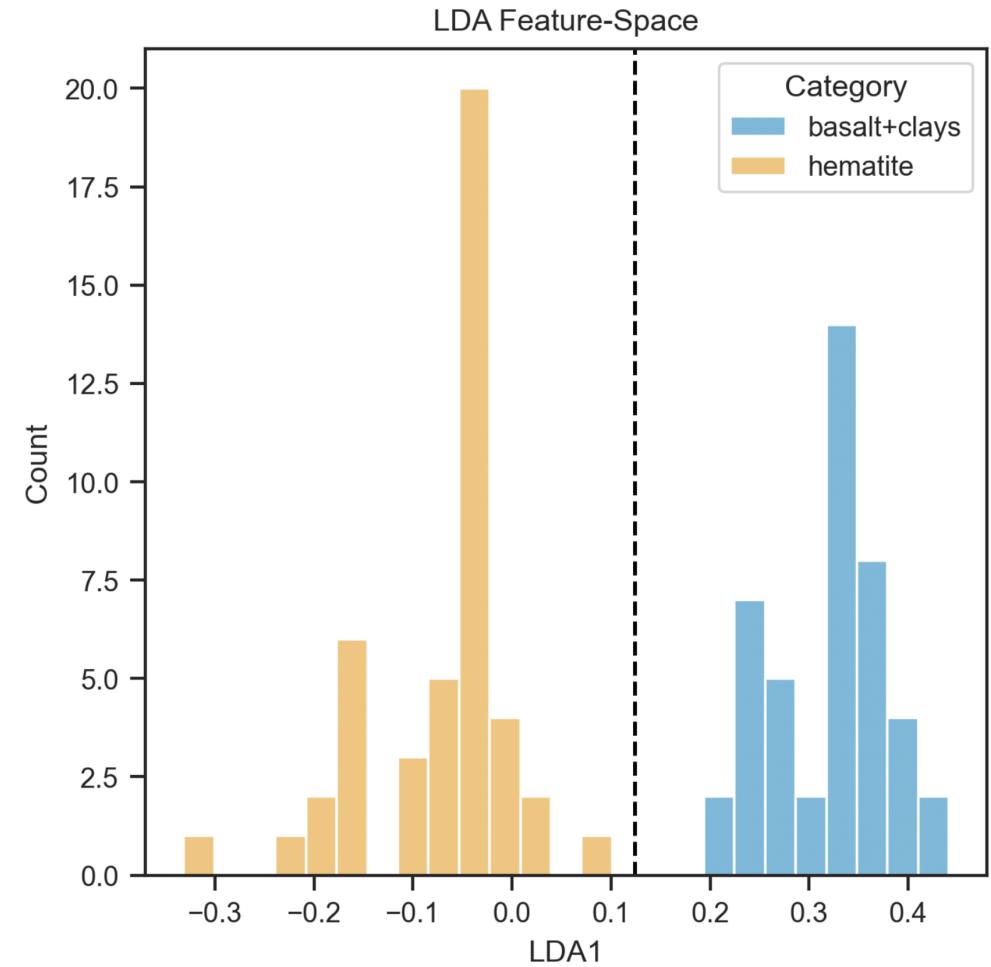
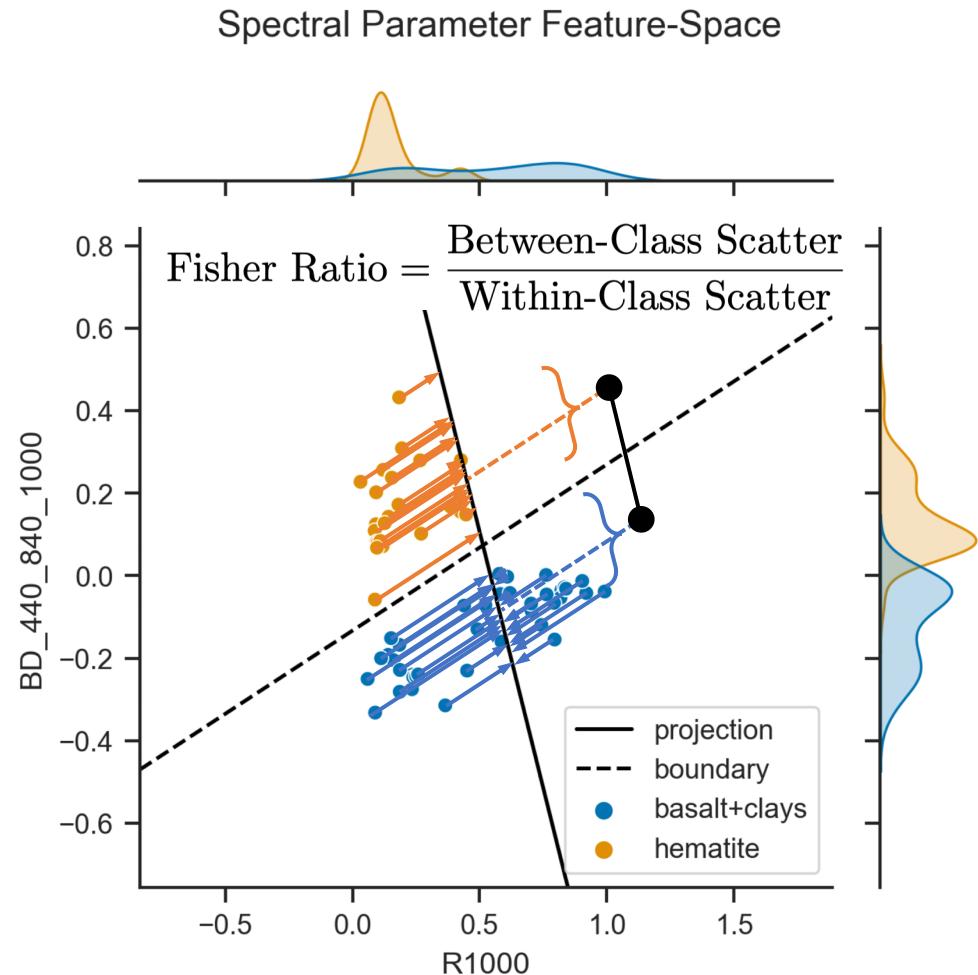
sptk: the Spectral Parameters Toolkit

Linear Discriminant Analysis



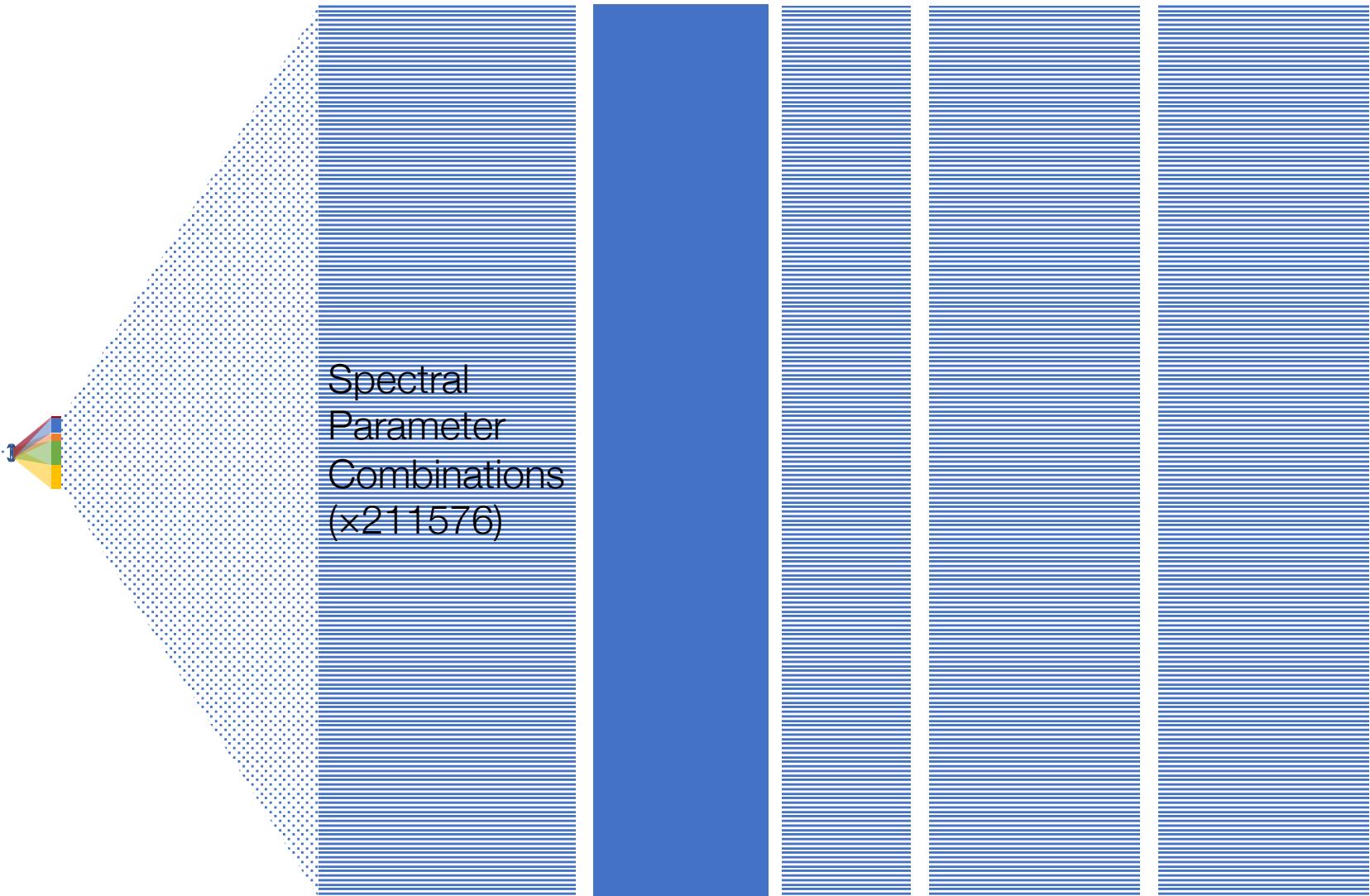
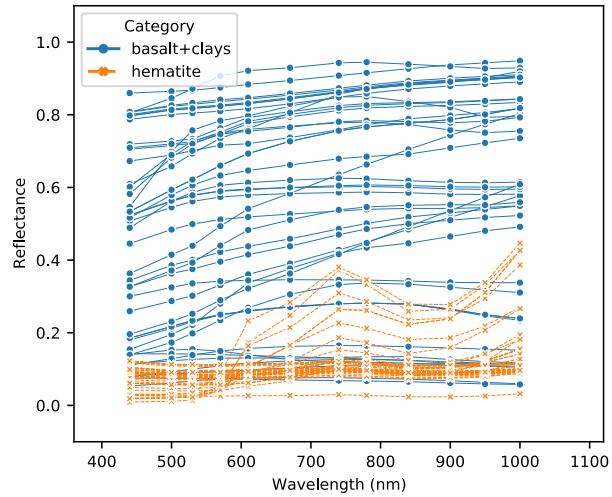
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Linear Discriminant Analysis



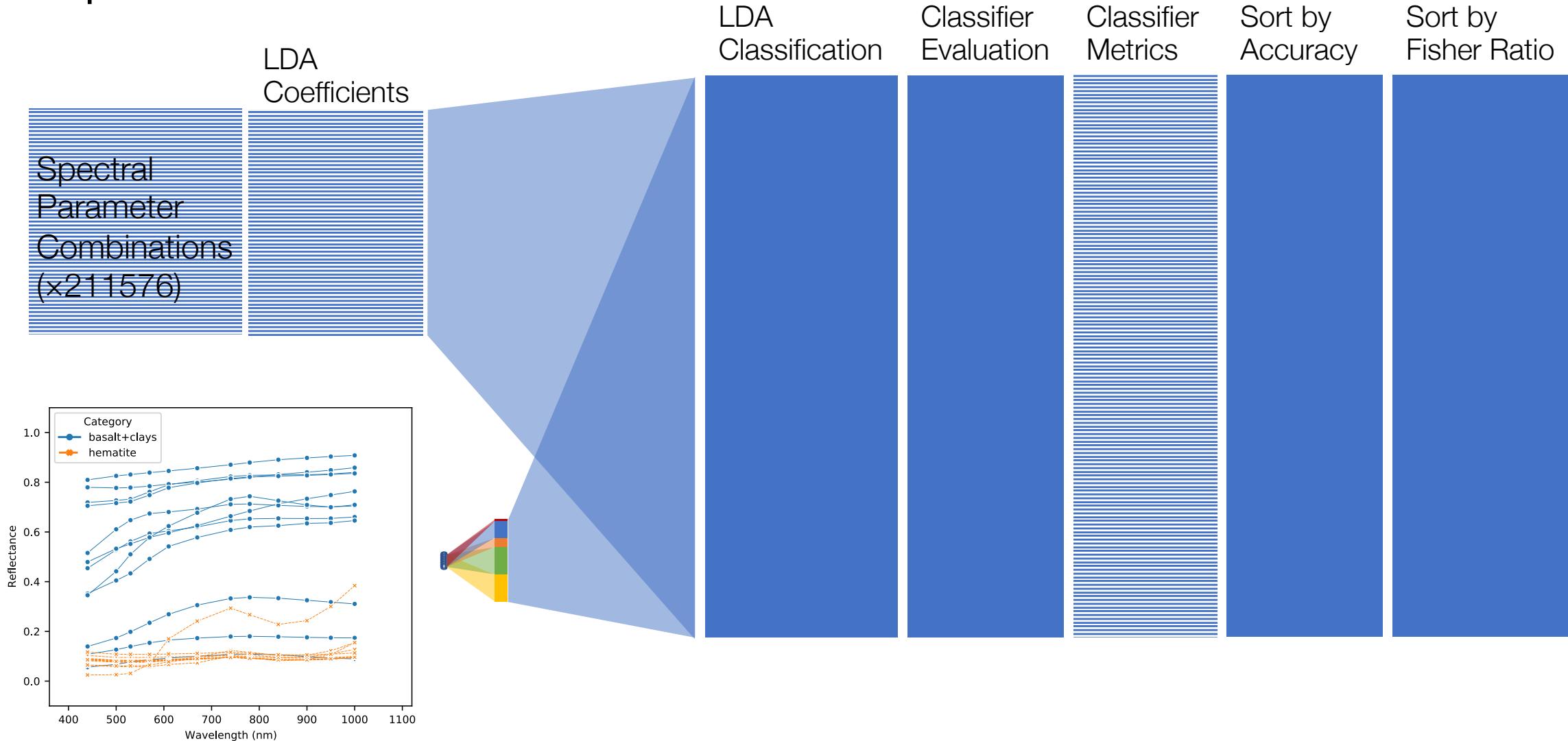
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Pipeline Overview



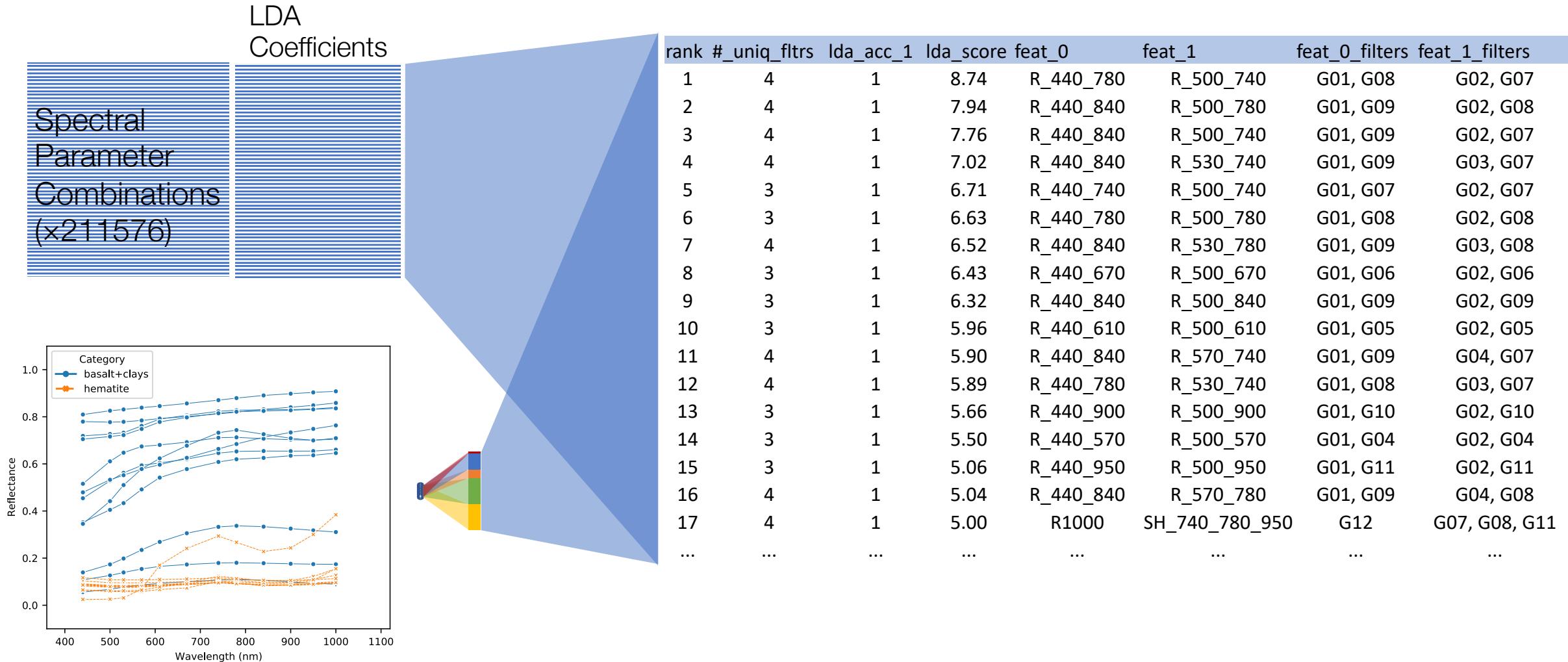
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Pipeline Overview



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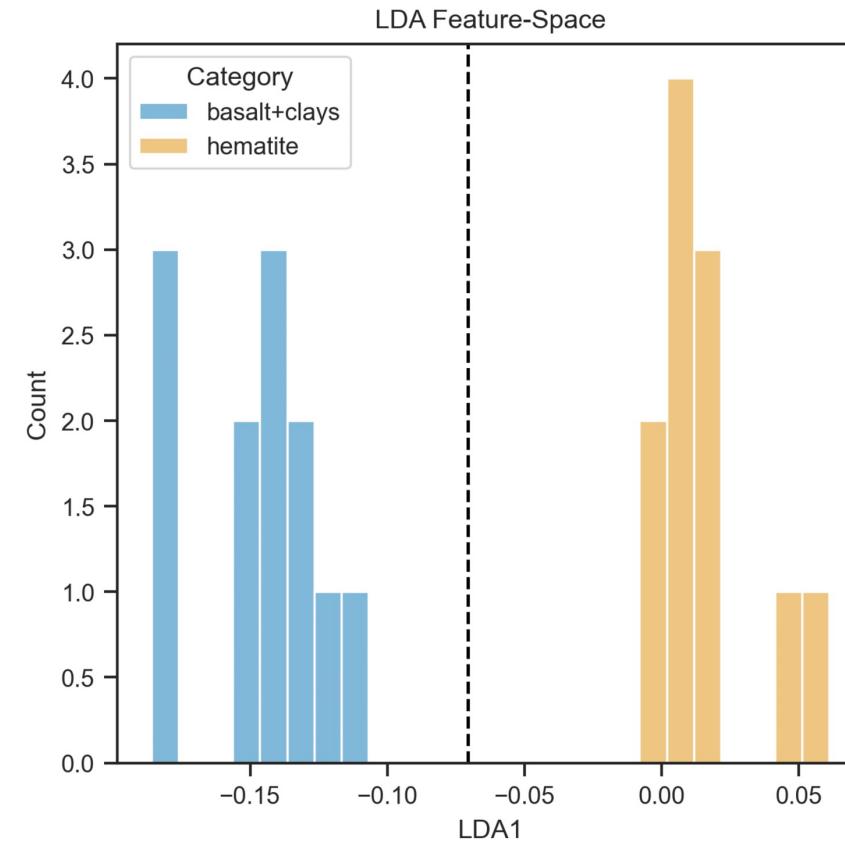
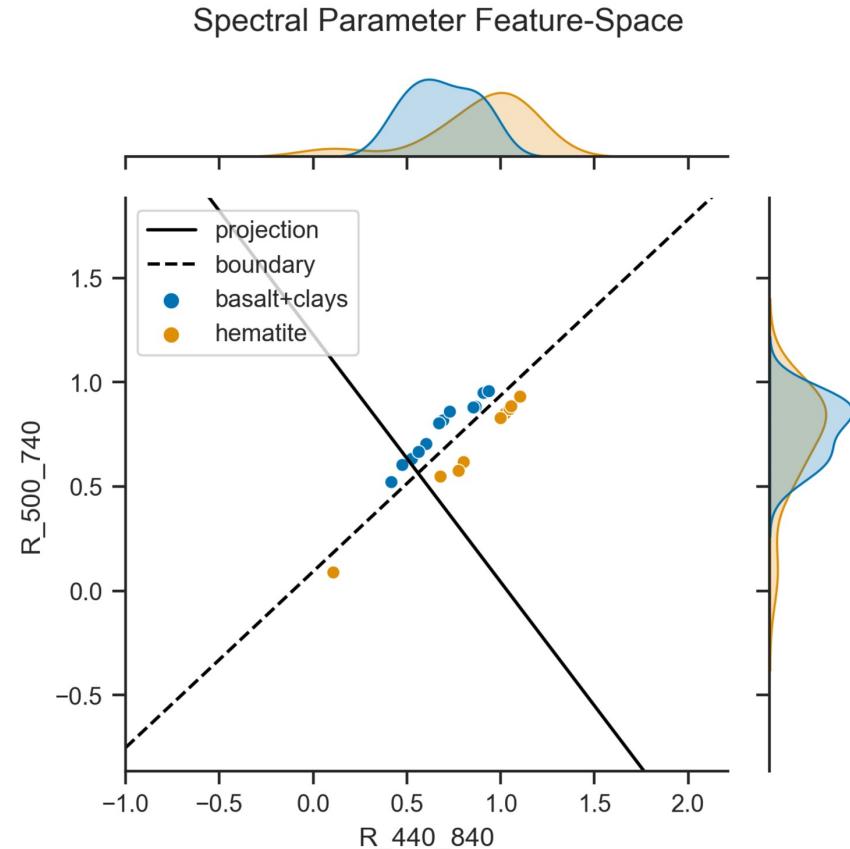
Pipeline Overview



sptk: the Spectral Parameters Toolkit

Results – Hematite vs Basalts & Clays

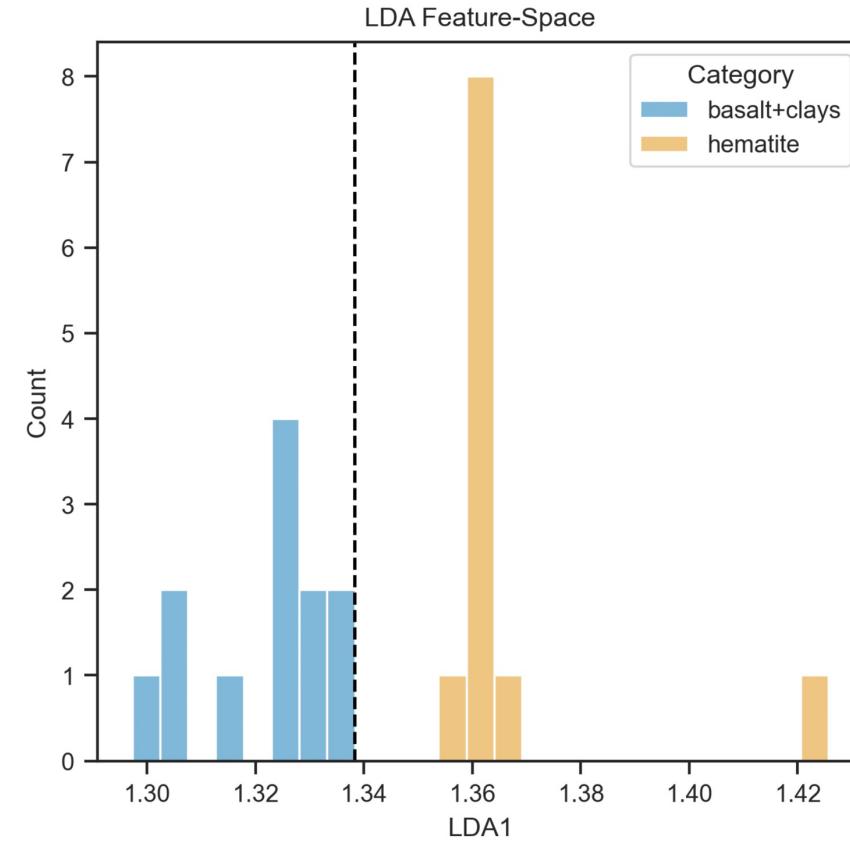
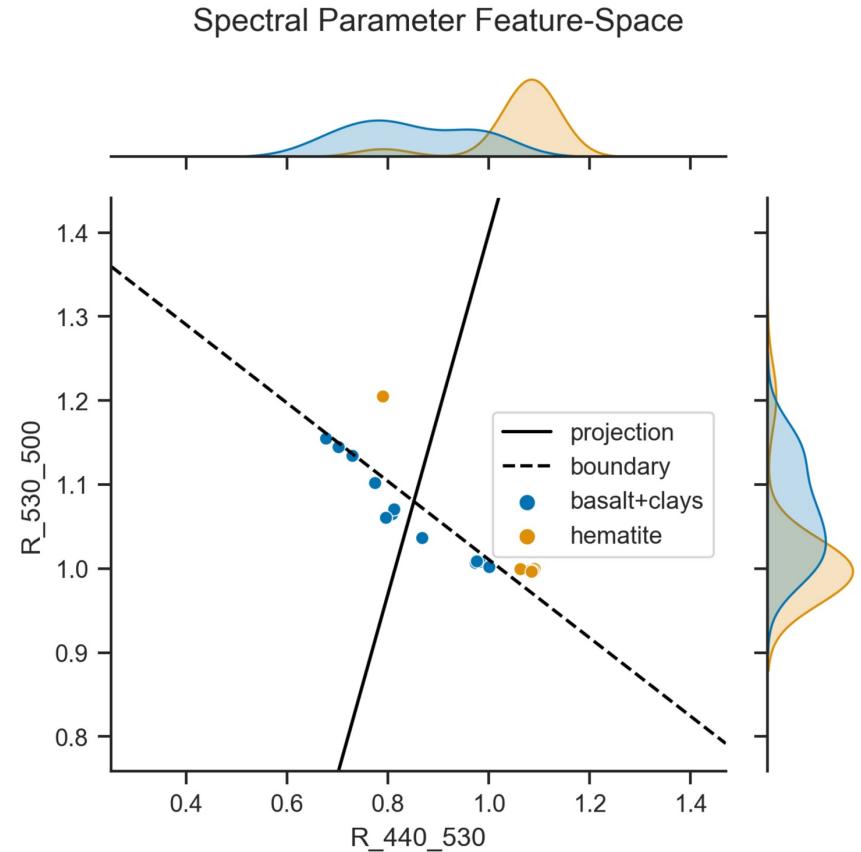
Rank 1, Accuracy 1.0, #Filters 4: G02, G07, G01, G09, SPs: R_500_740, R_440_840, test data



sptk: the Spectral Parameters Toolkit

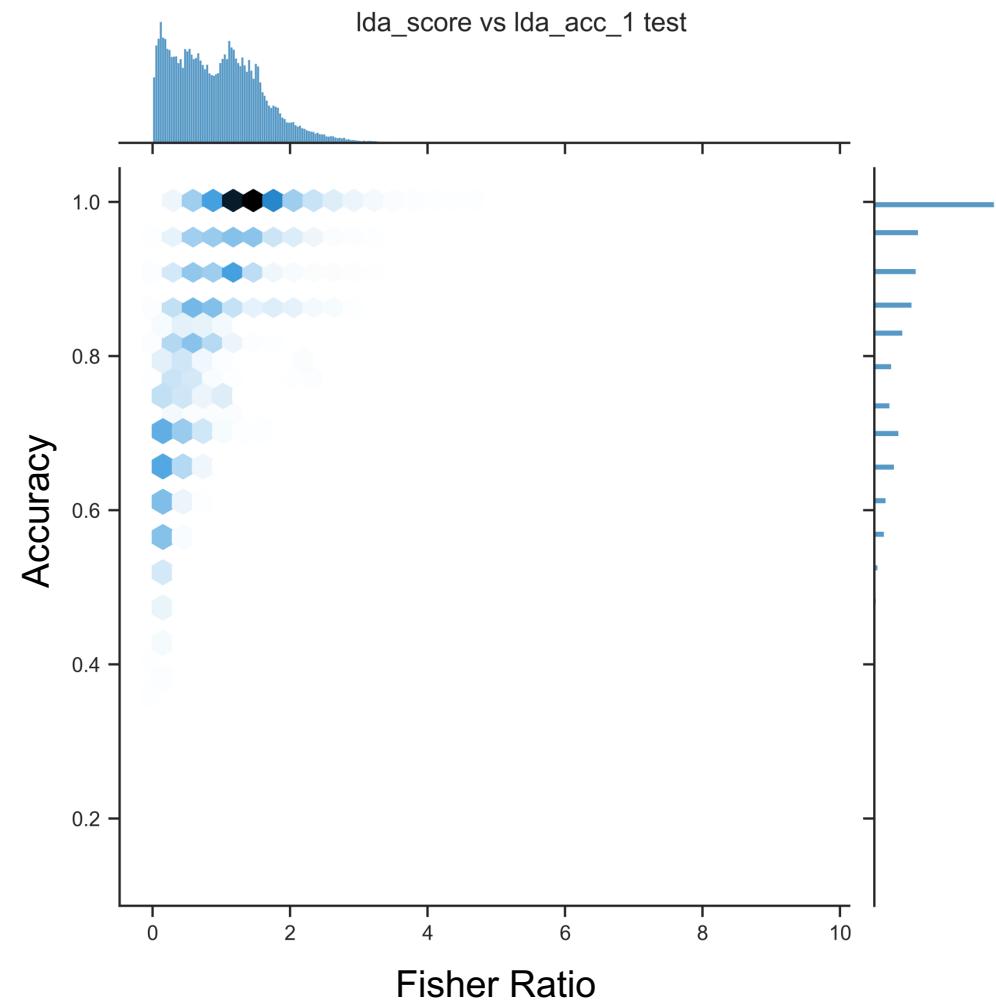
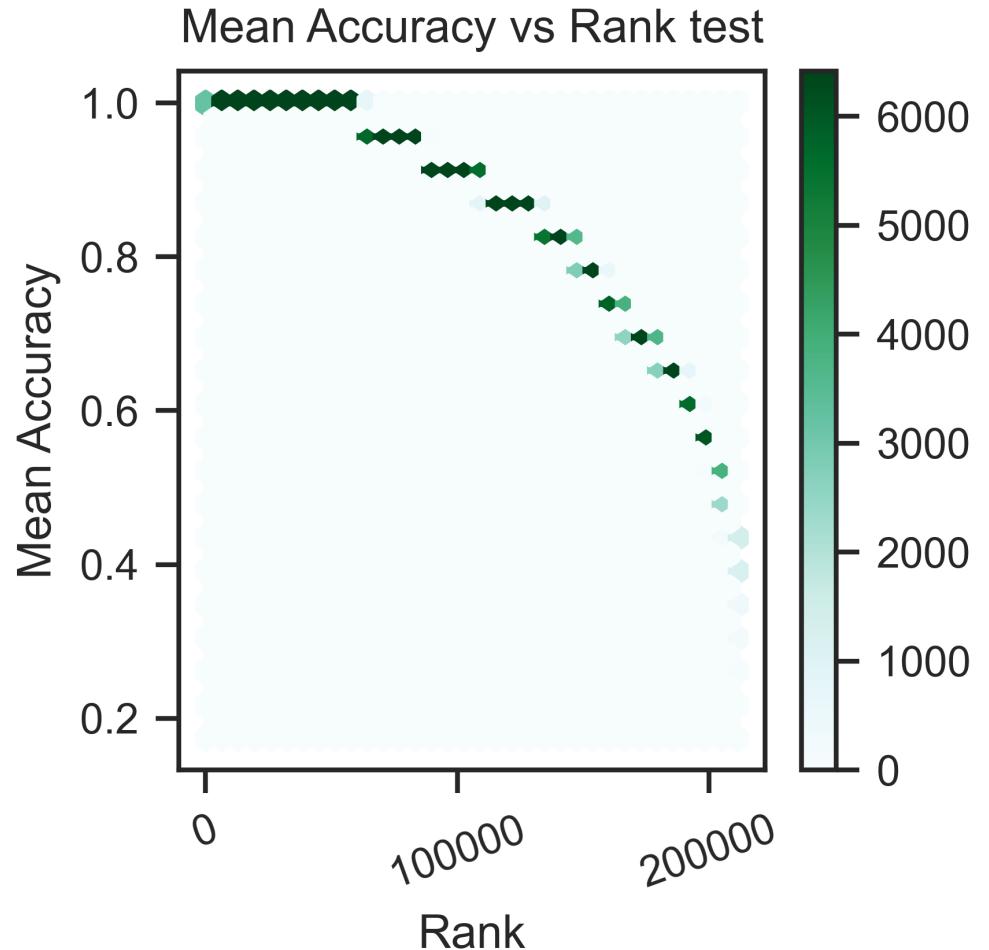
Results – Hematite vs Basalts & Clays

Rank 9, Accuracy 1.0, #Filters 3: G01, G03, G03, G02, SPs: R_440_530, R_530_500, test data



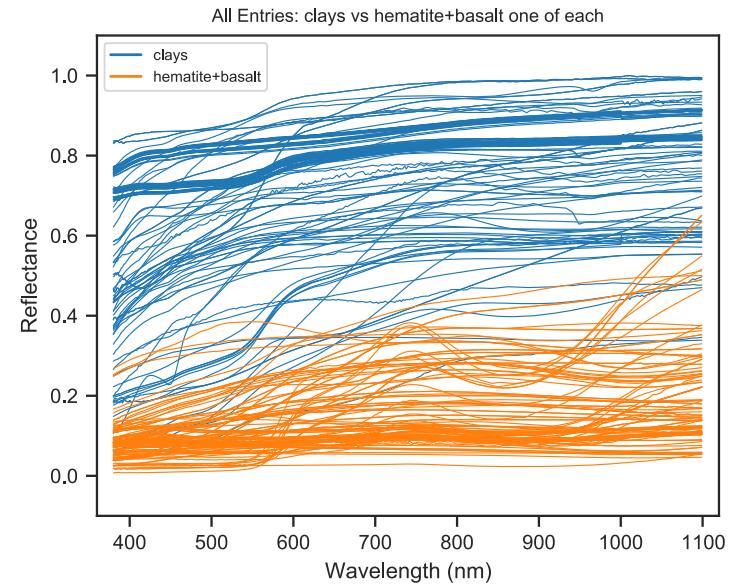
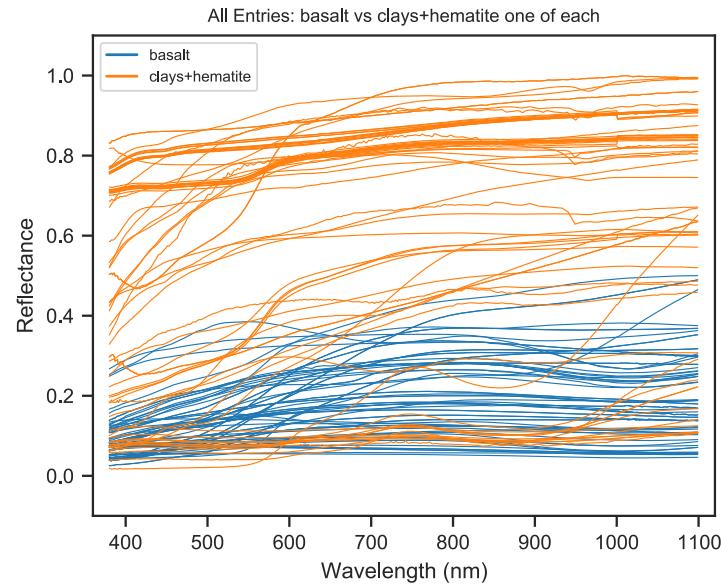
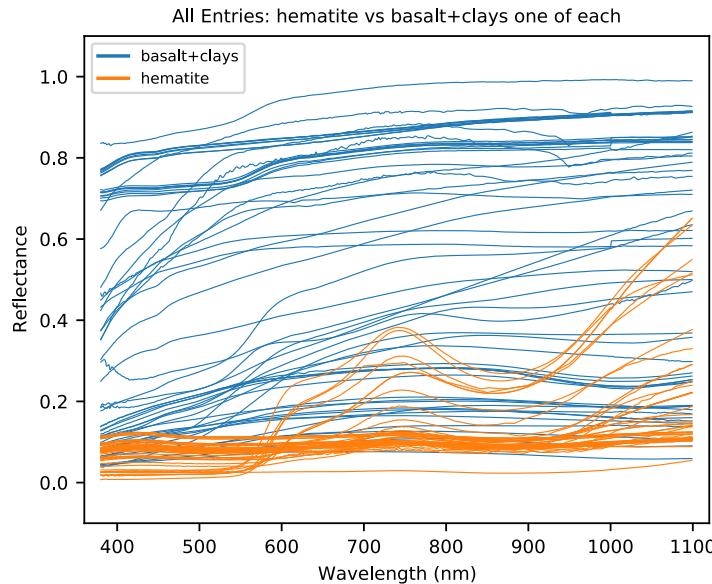
sptk: the Spectral Parameters Toolkit

Results – Hematite vs Basalts & Clays



sptk: the Spectral Parameters Toolkit

Multi-class separation



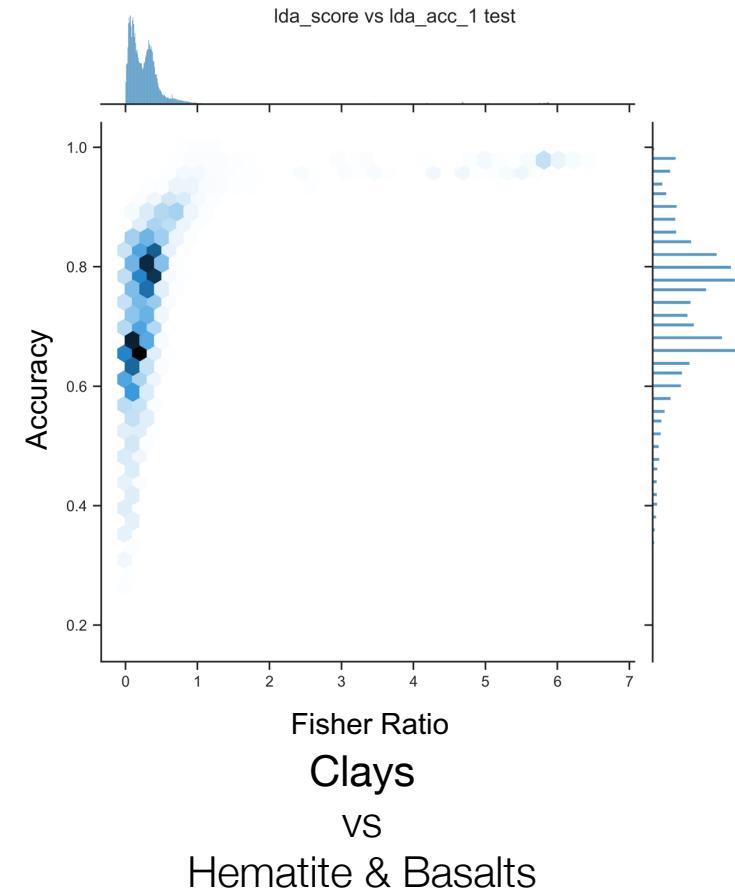
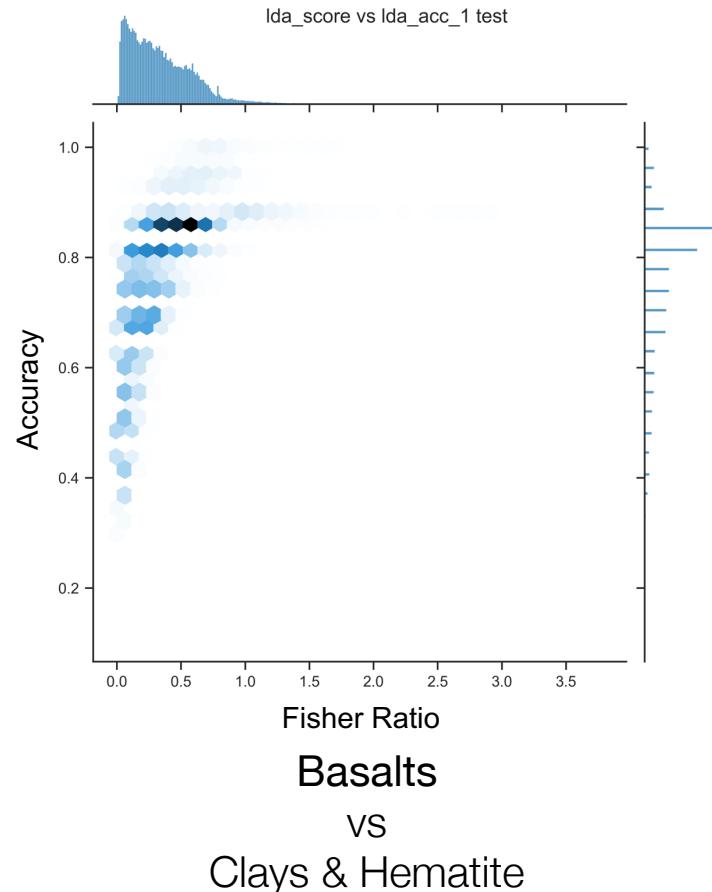
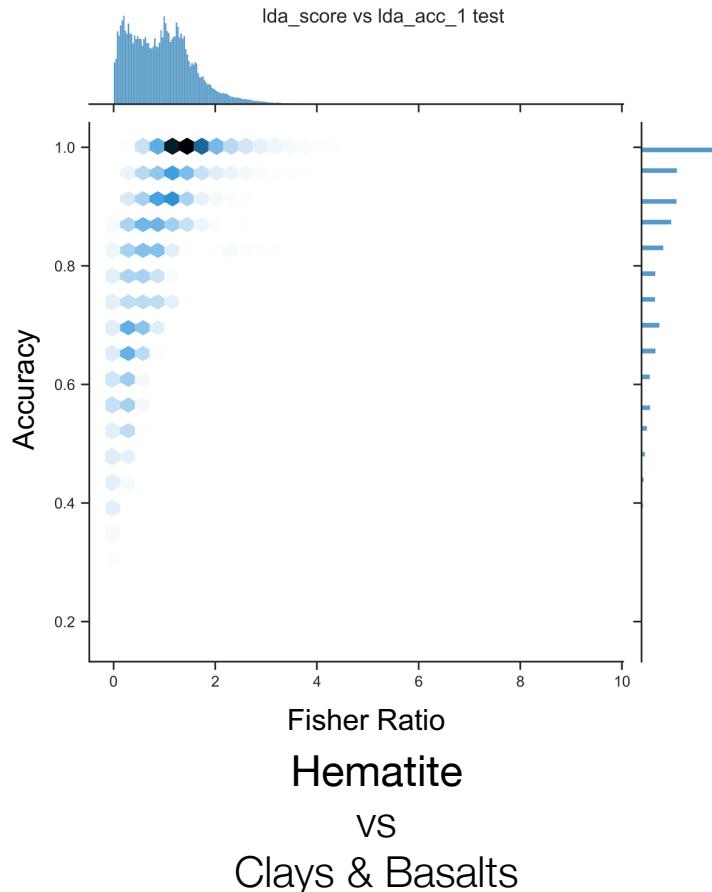
Hematite
VS
Clays & Basalts

Basalts
VS
Clays & Hematite

Clays
VS
Hematite & Basalts

sptk: the Spectral Parameters Toolkit

Multi-class separation

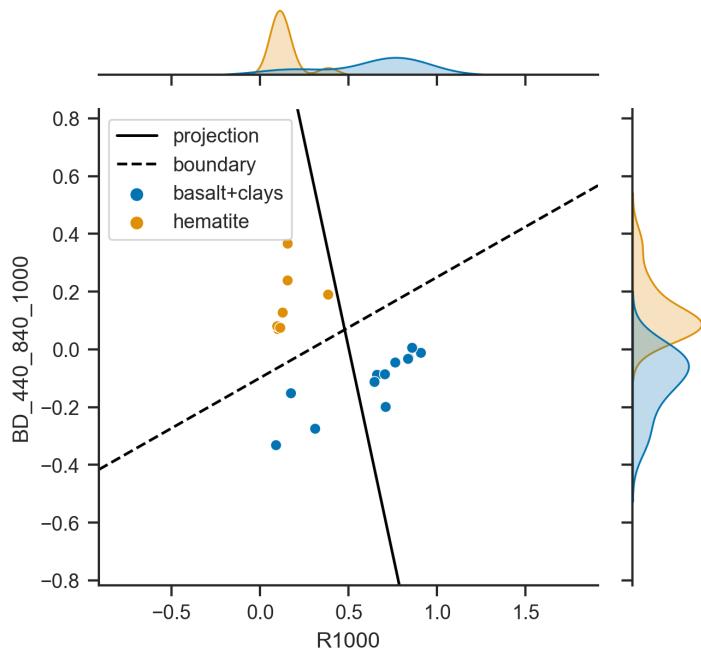


sptk: the Spectral Parameters Toolkit

Multi-class separation

Common Minimum Filter Set: 440 nm, 840 nm, 1000 nm

Spectral Parameter Feature-Space

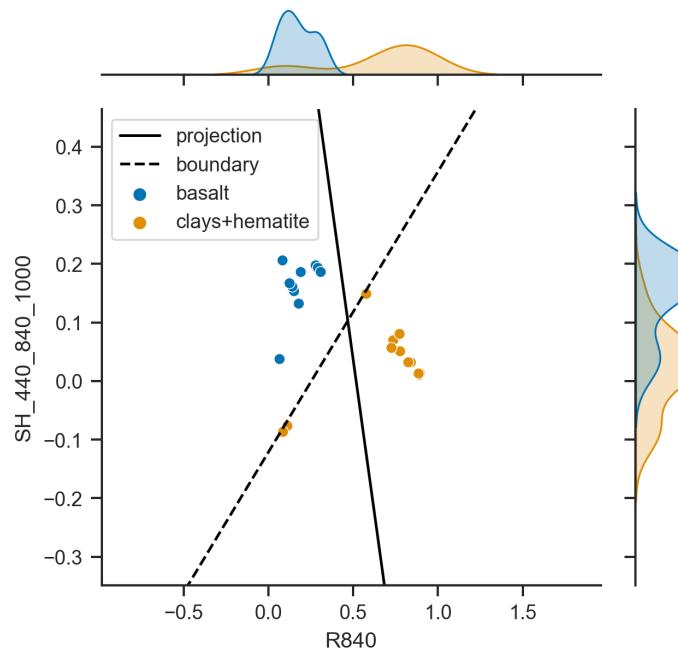


Hematite

VS

Clays & Basalts

Spectral Parameter Feature-Space

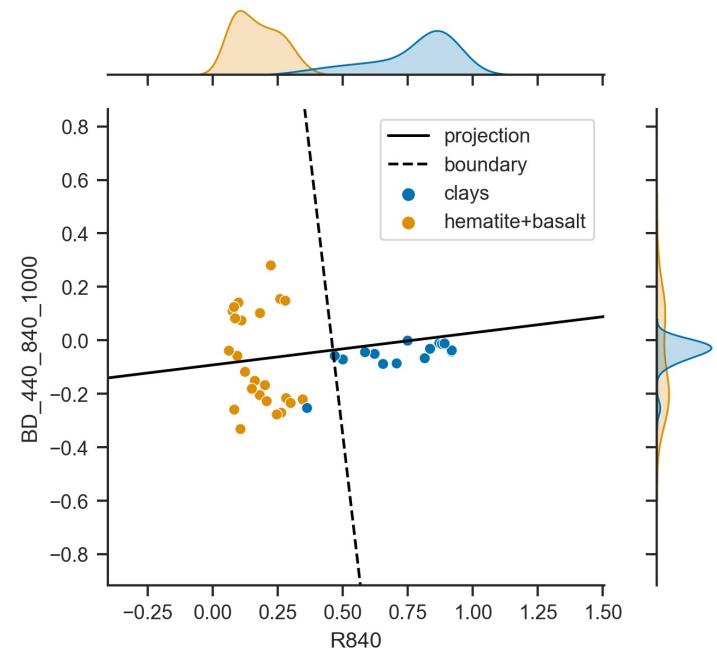


Basalts

VS

Clays & Hematite

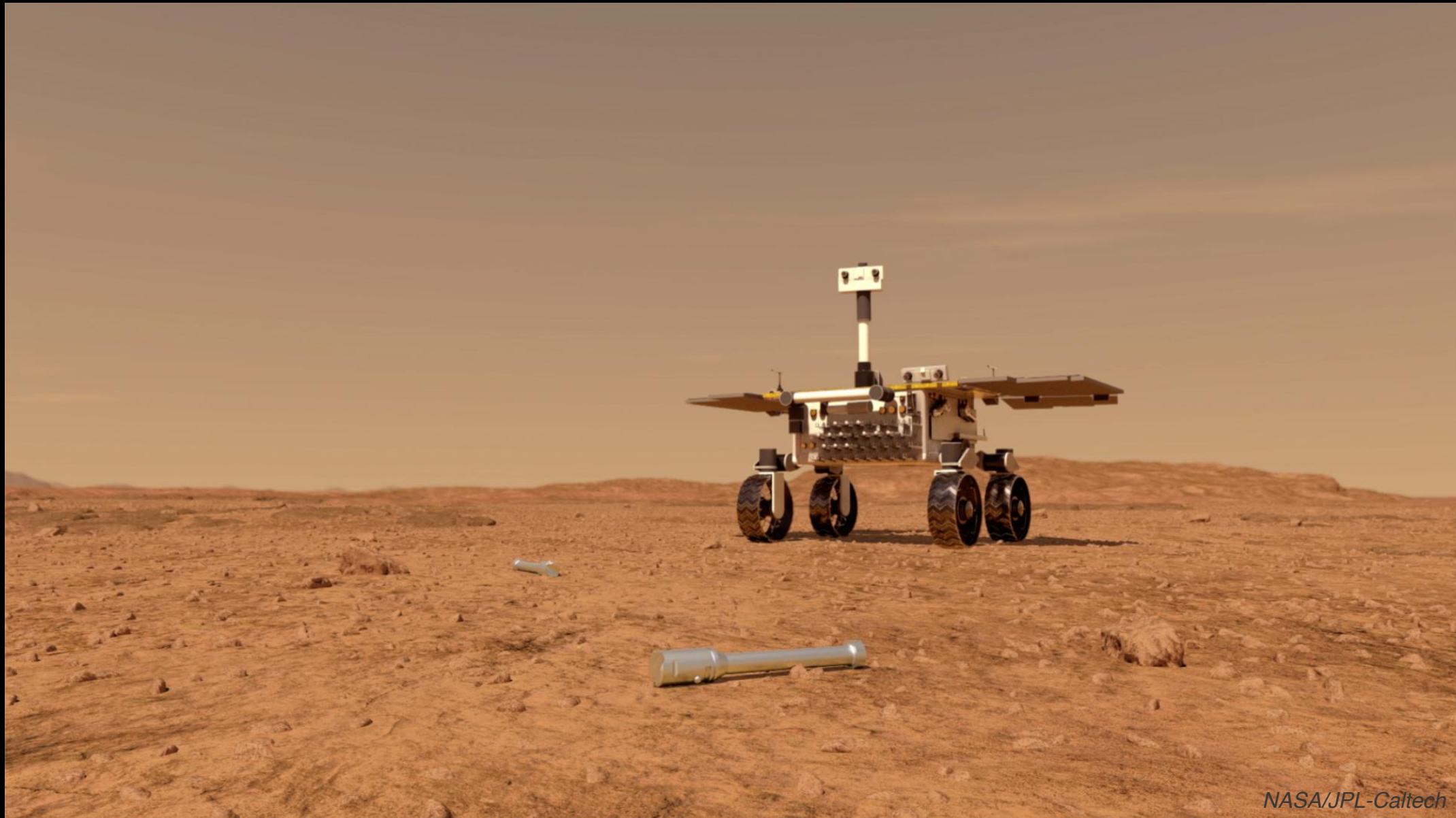
Spectral Parameter Feature-Space



Clays

VS

Hematite & Basalts



NASA/JPL-Caltech

Seeing Minerals Clearly

Learning Dimension Reductions on Spectral Reflectance Libraries for Efficient In Situ Multispectral Image Acquisition and Analysis

Summary

- Find the multispectral filter subset, and how to combine them, to separate a target from a background, by:
 - applying LDA on all pair combinations of all permutations of spectral parameters,
 - and ranking by Fisher Ratio and classifier accuracy
- Hematite can be separated from Basalts & Clays with ~50,000 spectral parameter combinations
- Hematite, Basalts and Clays can be optimally separated with 3 filters

