

Seeing Minerals Clearly

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

R. B. Stabbins¹, P. M. Grindrod¹, S. Motaghian¹,

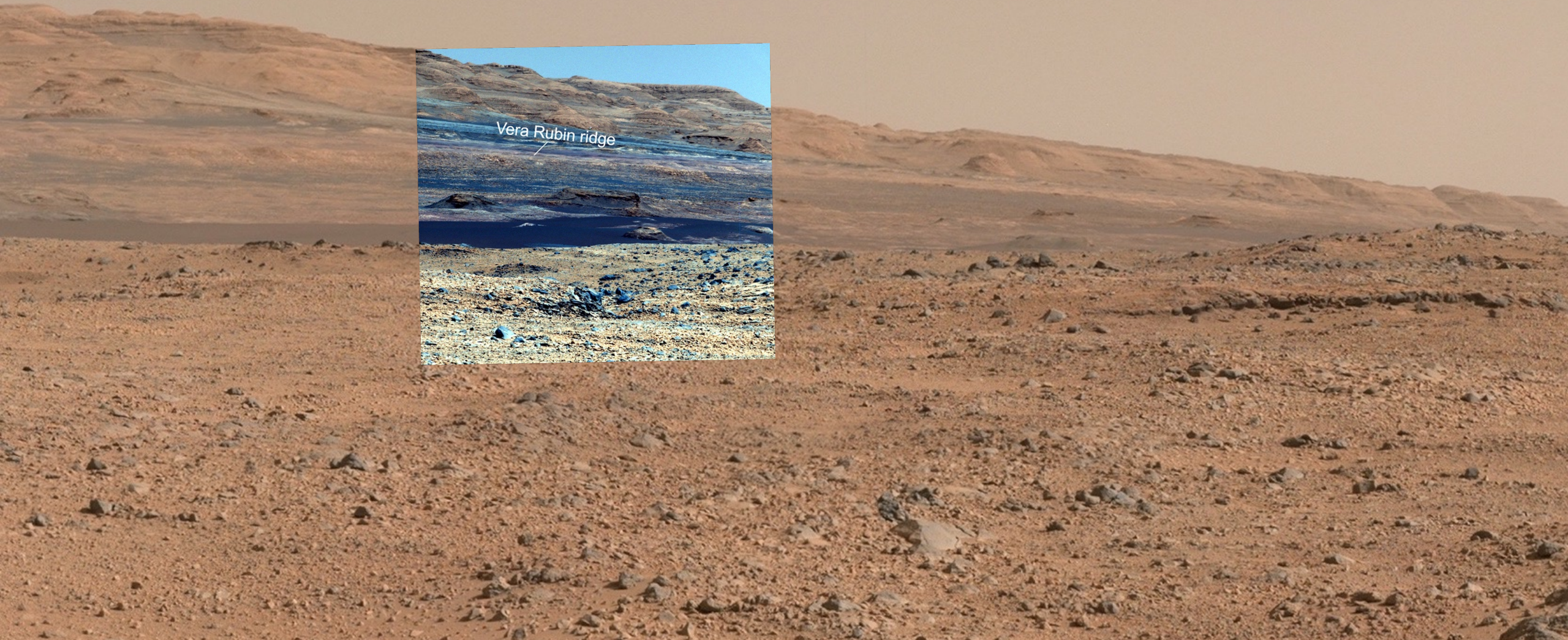
E. J. Allender², C. R. Cousins²

and the PanCam Science Team

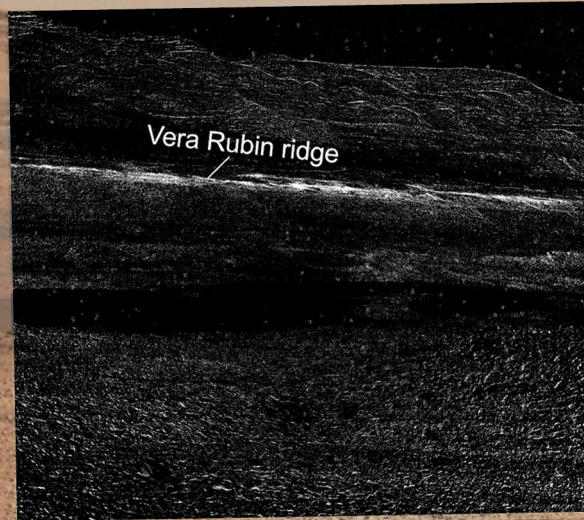
1. Mineral & Planetary Sciences Division, Department of Earth Science, Natural History Museum, London, UK
2. School of Earth and Environmental Sciences, University of St Andrews, UK



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

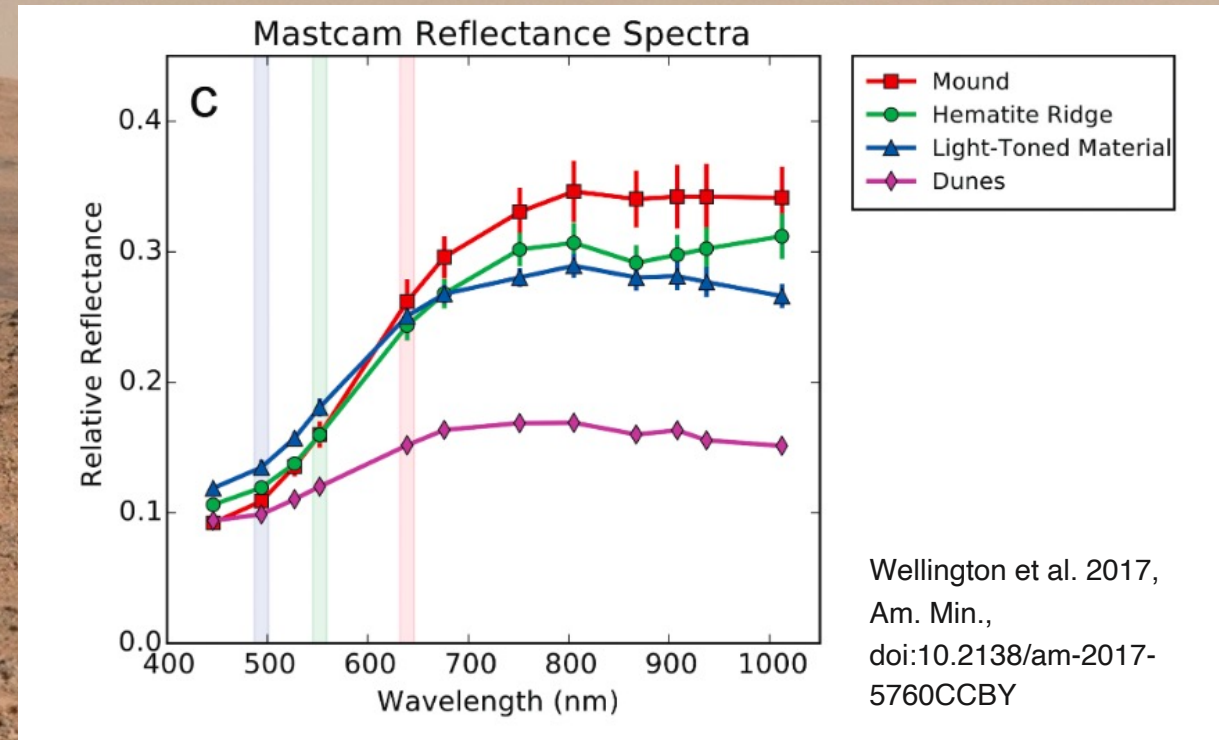
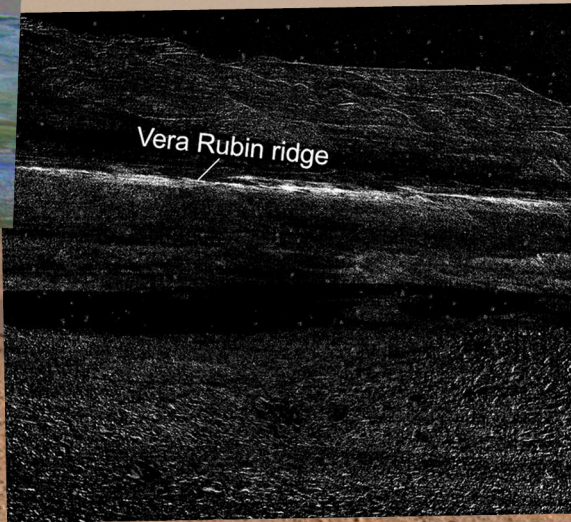
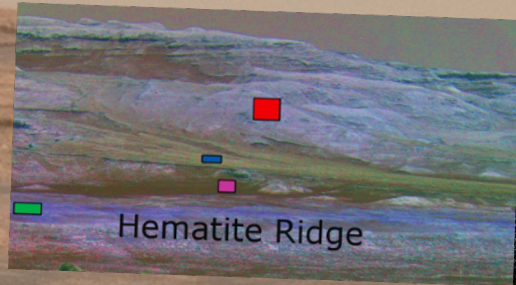


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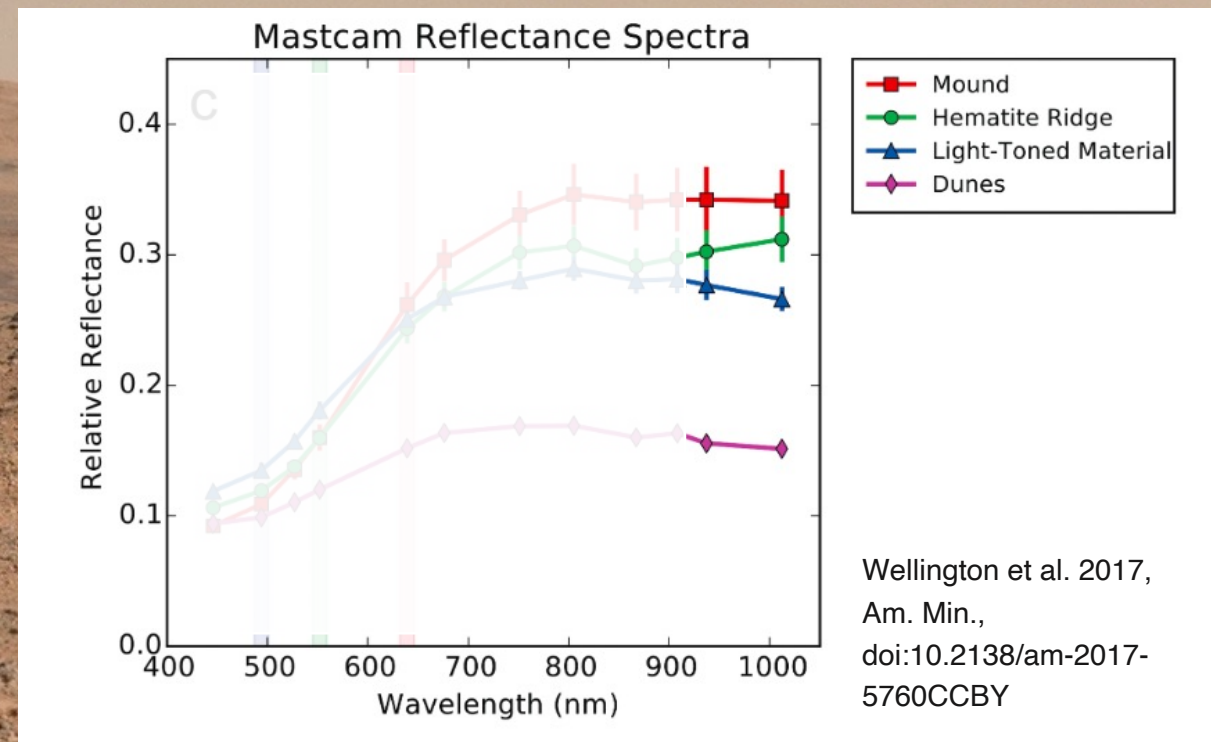
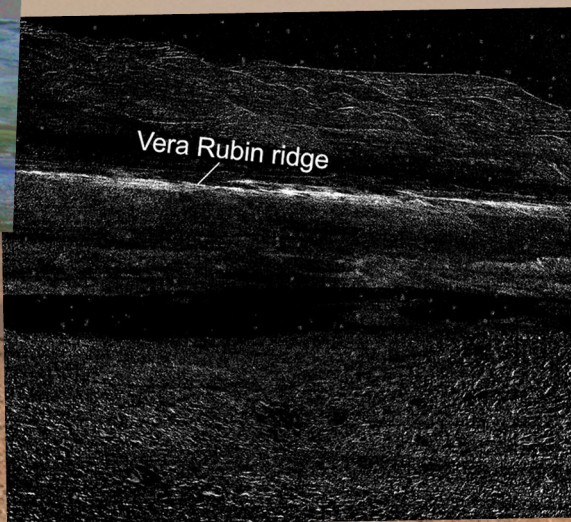
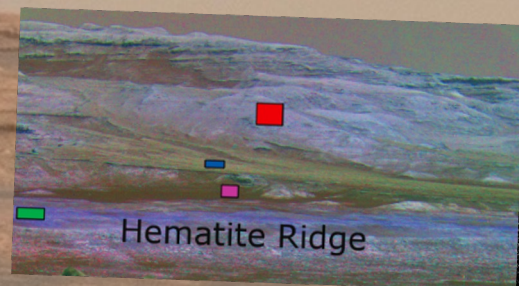
Wellington et al. 2017, Am. Min.,
doi:10.2138/am-2017-5760CCBY

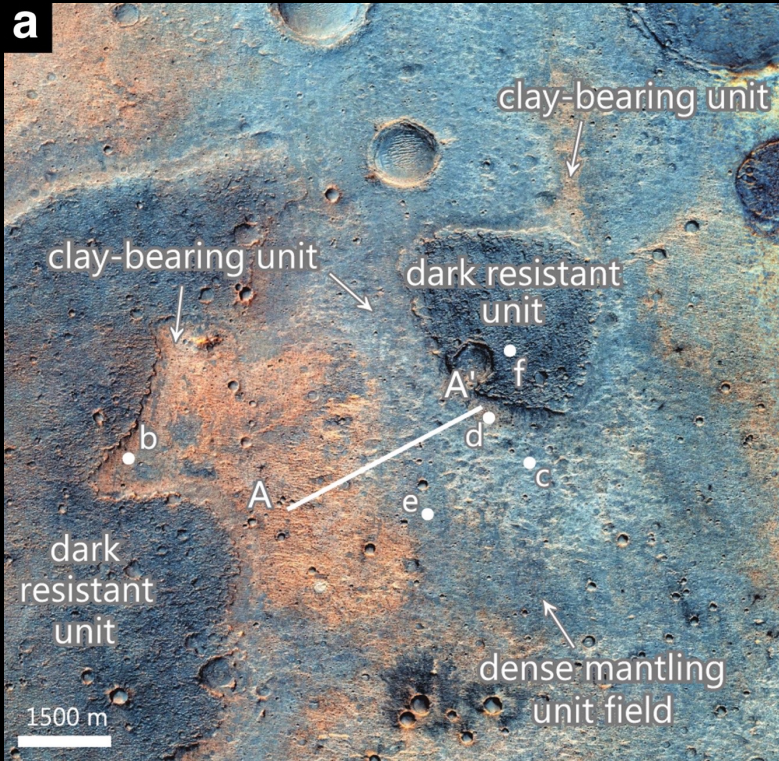
Fraeman et al. 2020, JGR Planets,
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Wellington et al. 2017, Am. Min.,
doi:10.2138/am-2017-5760CCBY

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





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

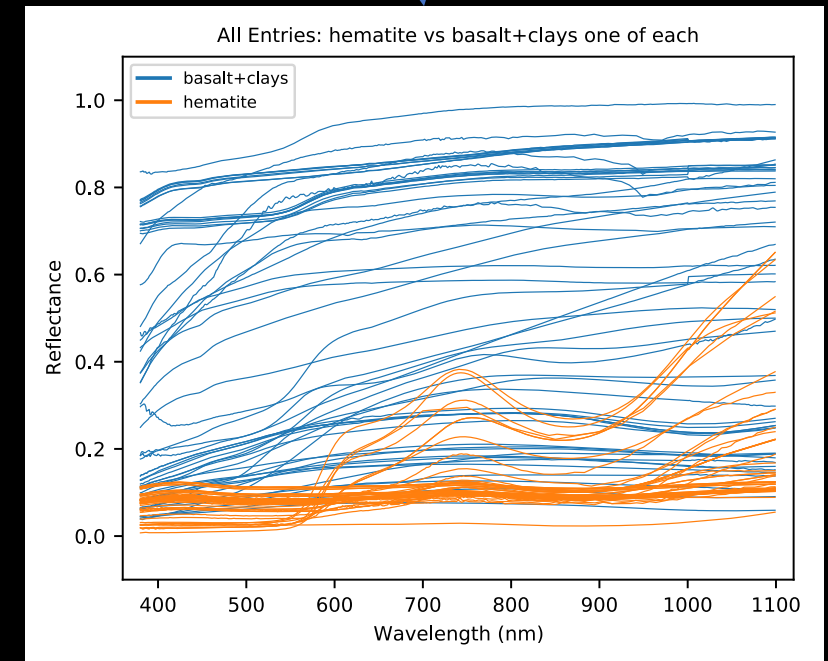
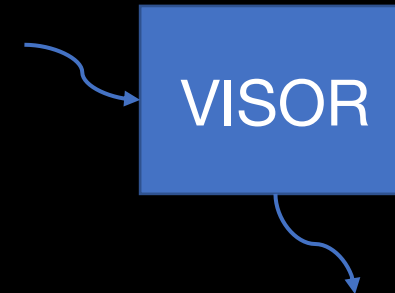
target: Hematite

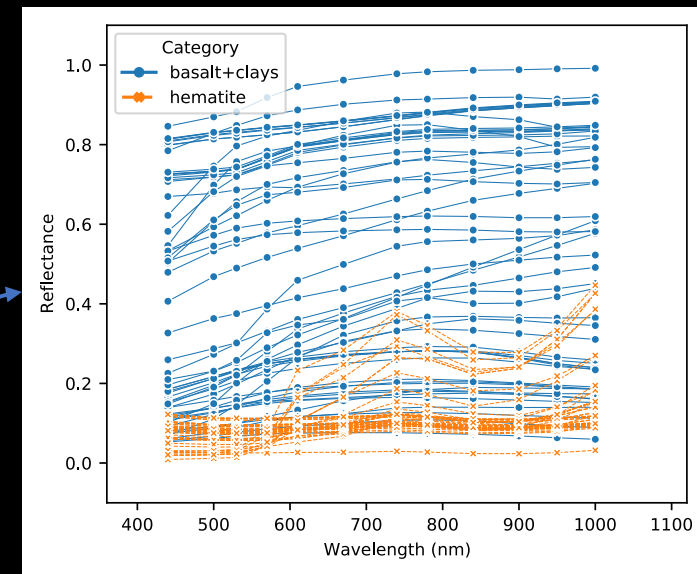
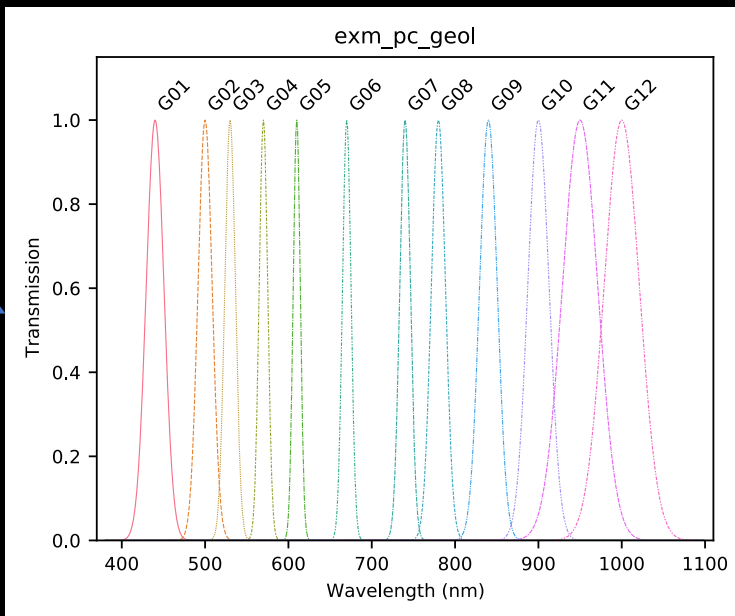
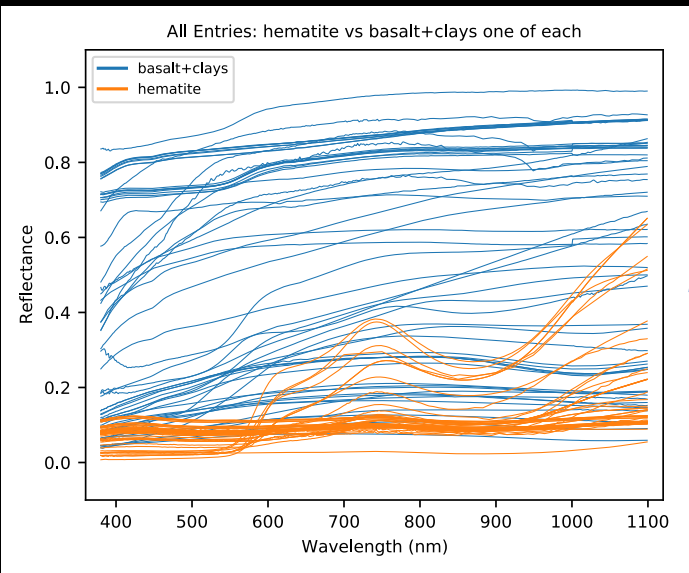
- hematite (×83)

background: Clays & Basalts

- vermiculite (×26)
- saponite (×102)
- montmorillonite (×144)
- basalt (×71)
- basaltic soil (×10)

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

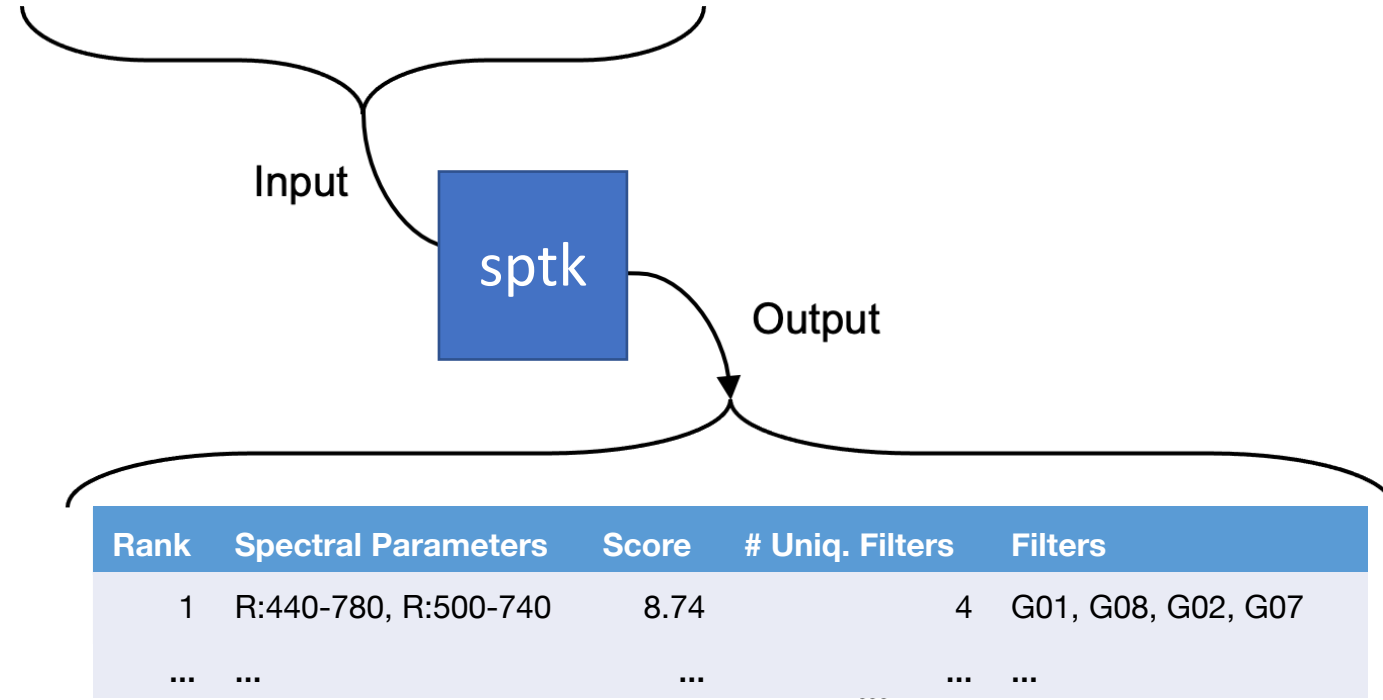




sptk: the Spectral Parameters Toolkit

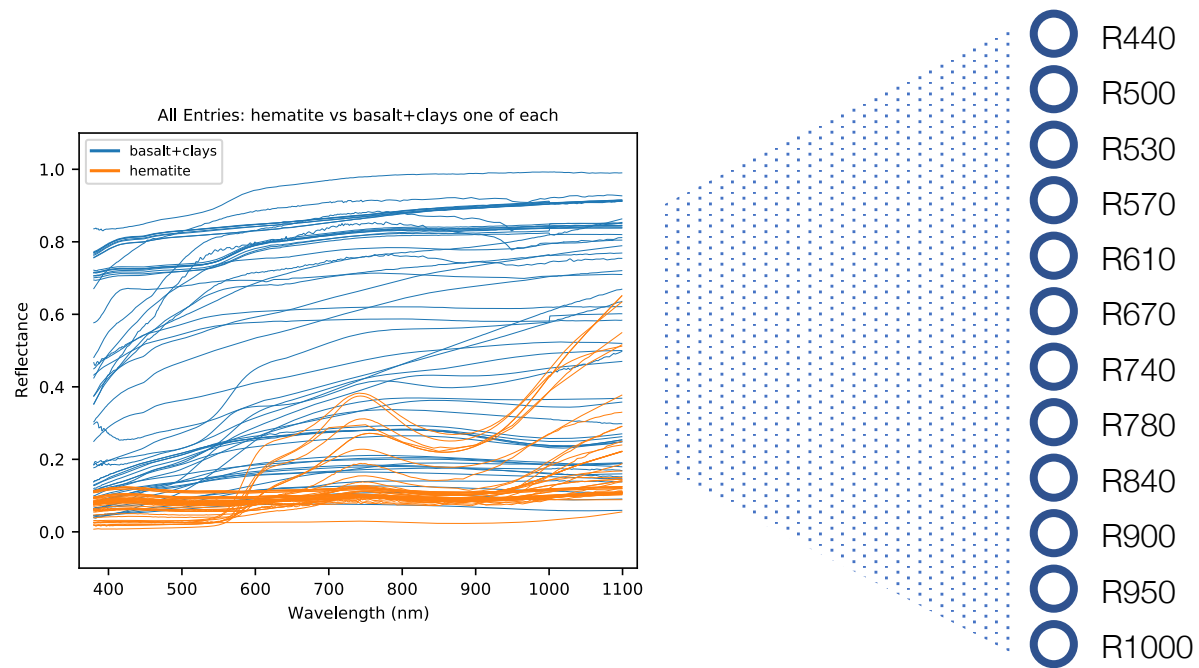
A python library for exploring multispectral sampling

- target material
- background materials
- filters



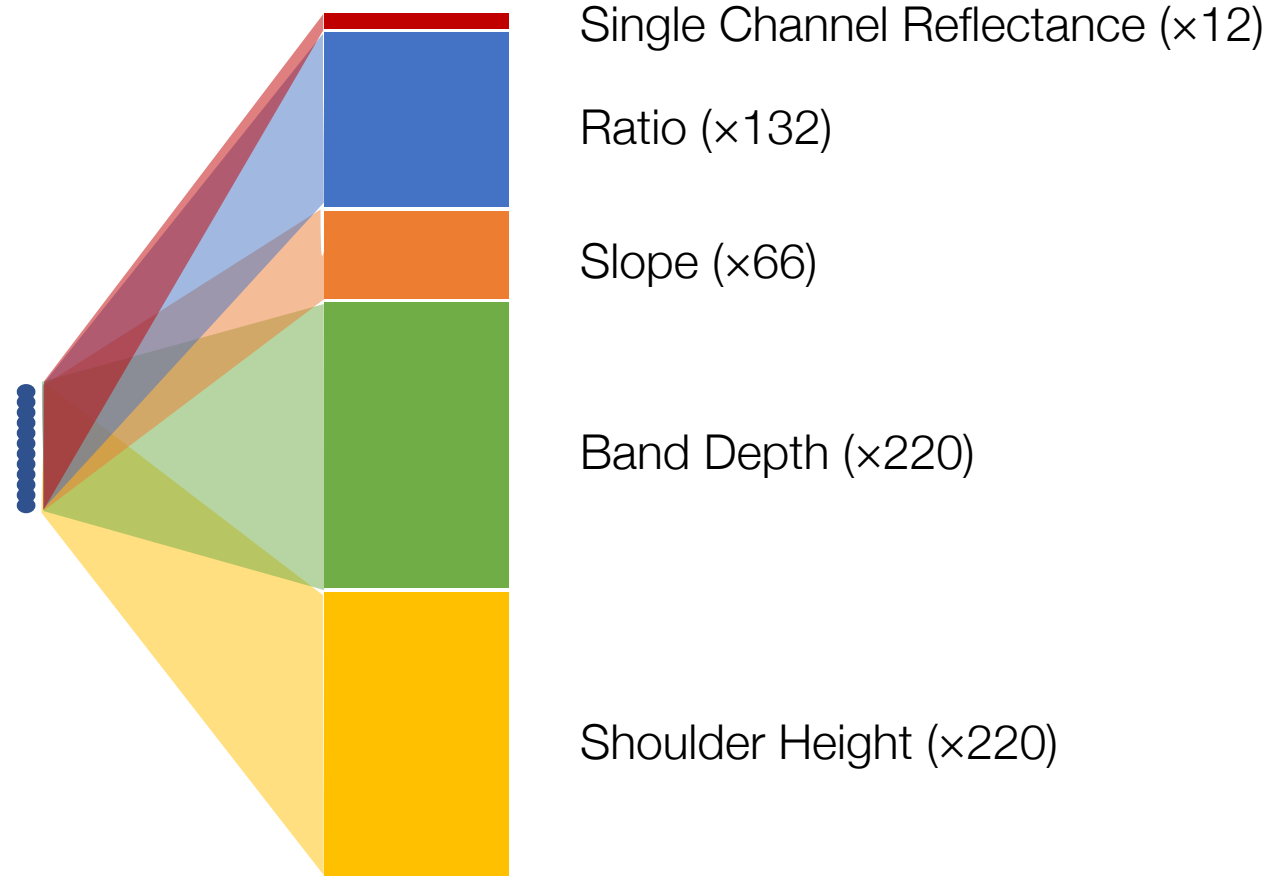
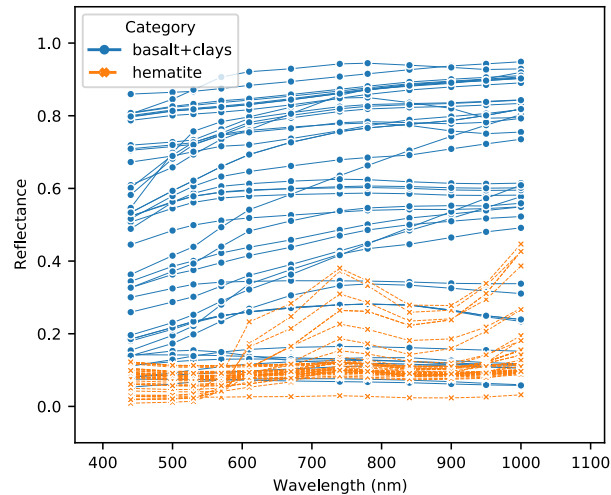
sptk: the Spectral Parameters Toolkit

Pipeline Overview



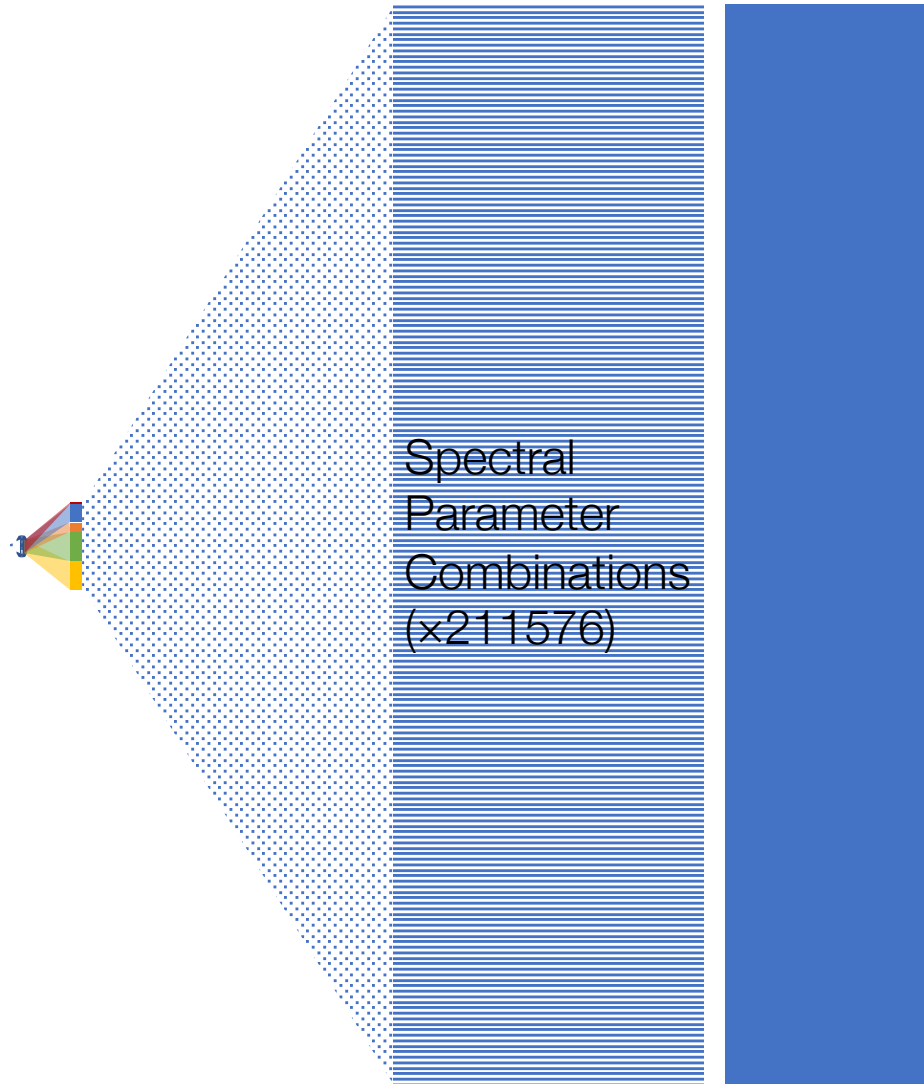
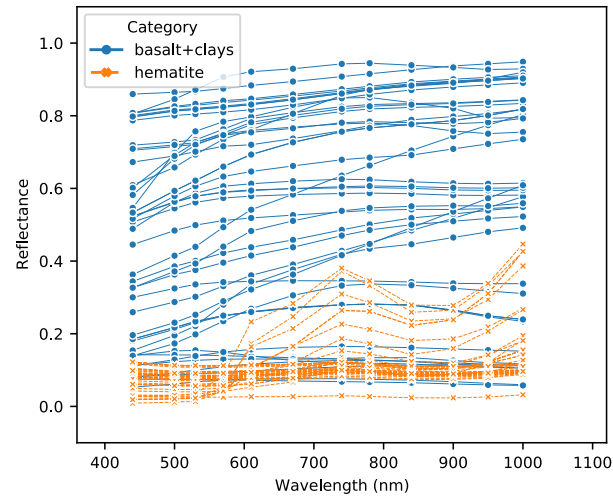
sptk: the Spectral Parameters Toolkit

Pipeline Overview



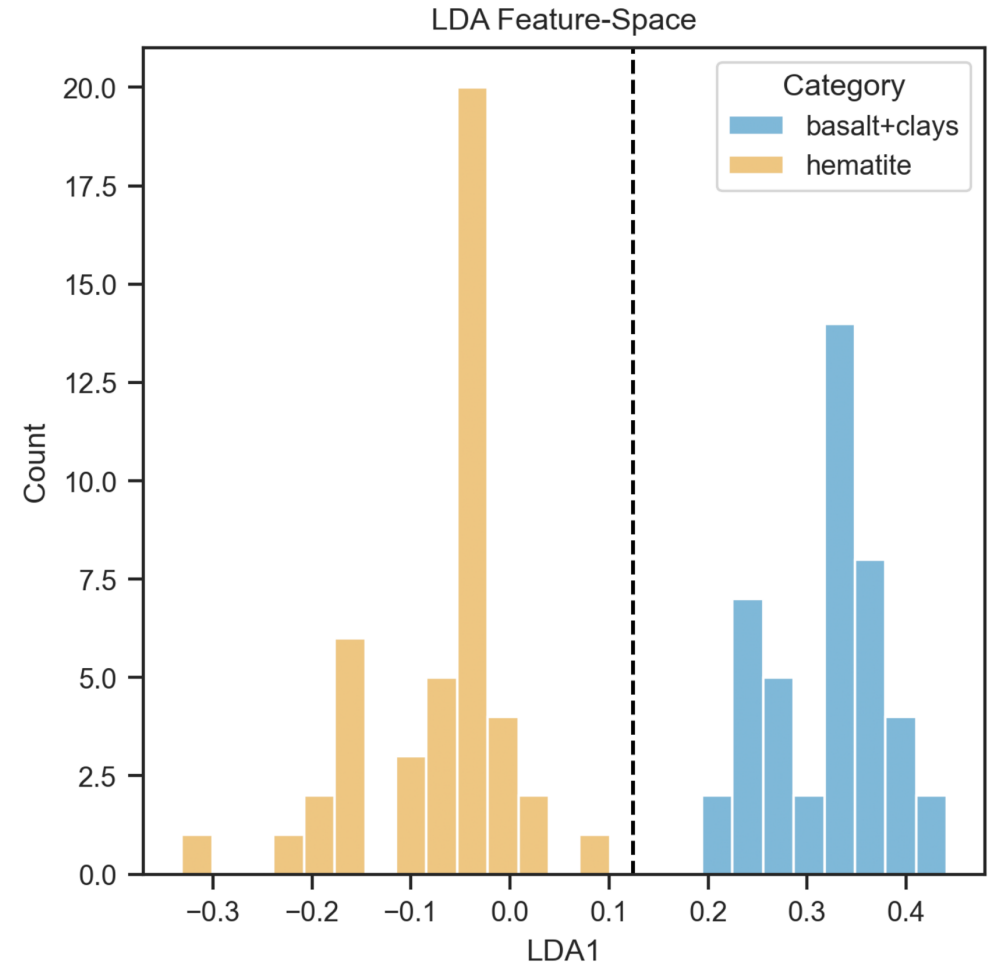
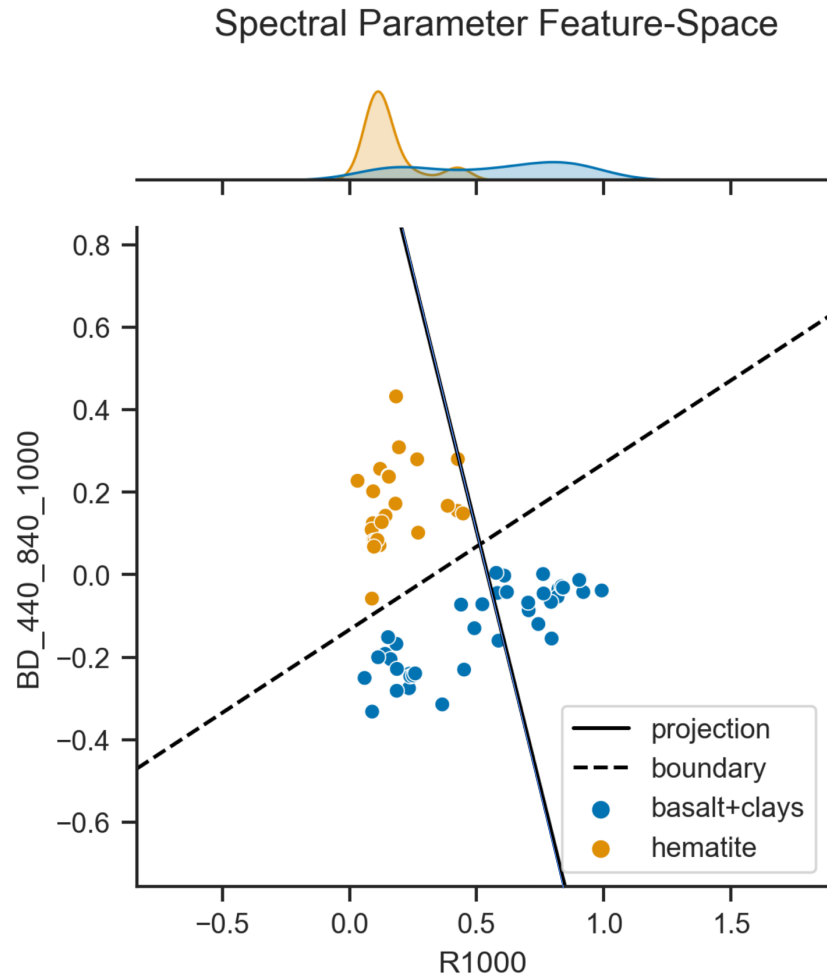
sptk: the Spectral Parameters Toolkit

Pipeline Overview



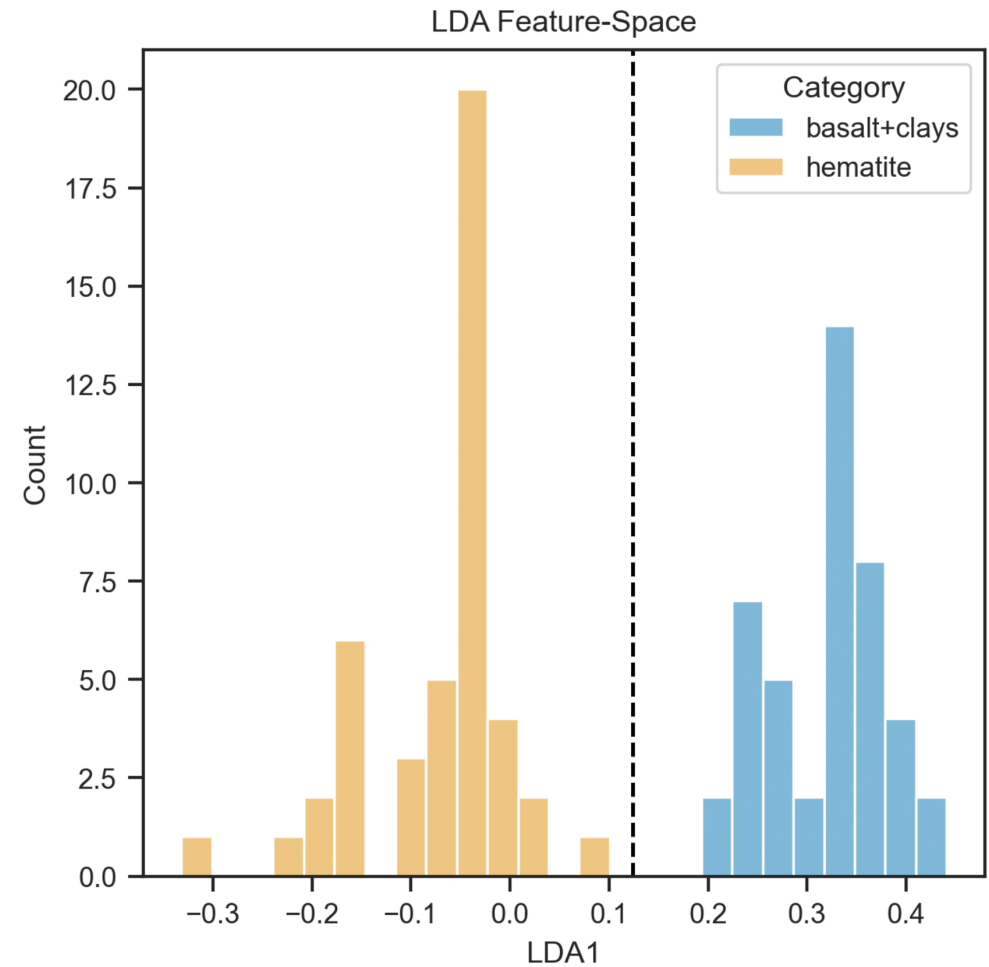
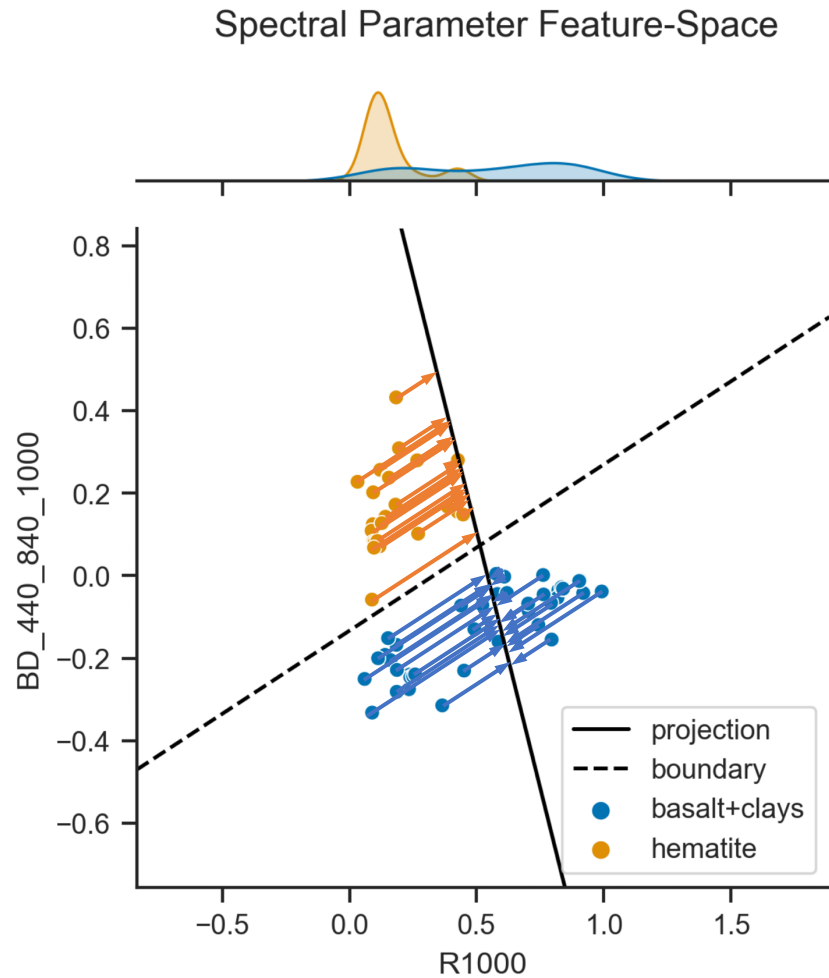
sptk: the Spectral Parameters Toolkit

Linear Discriminant Analysis



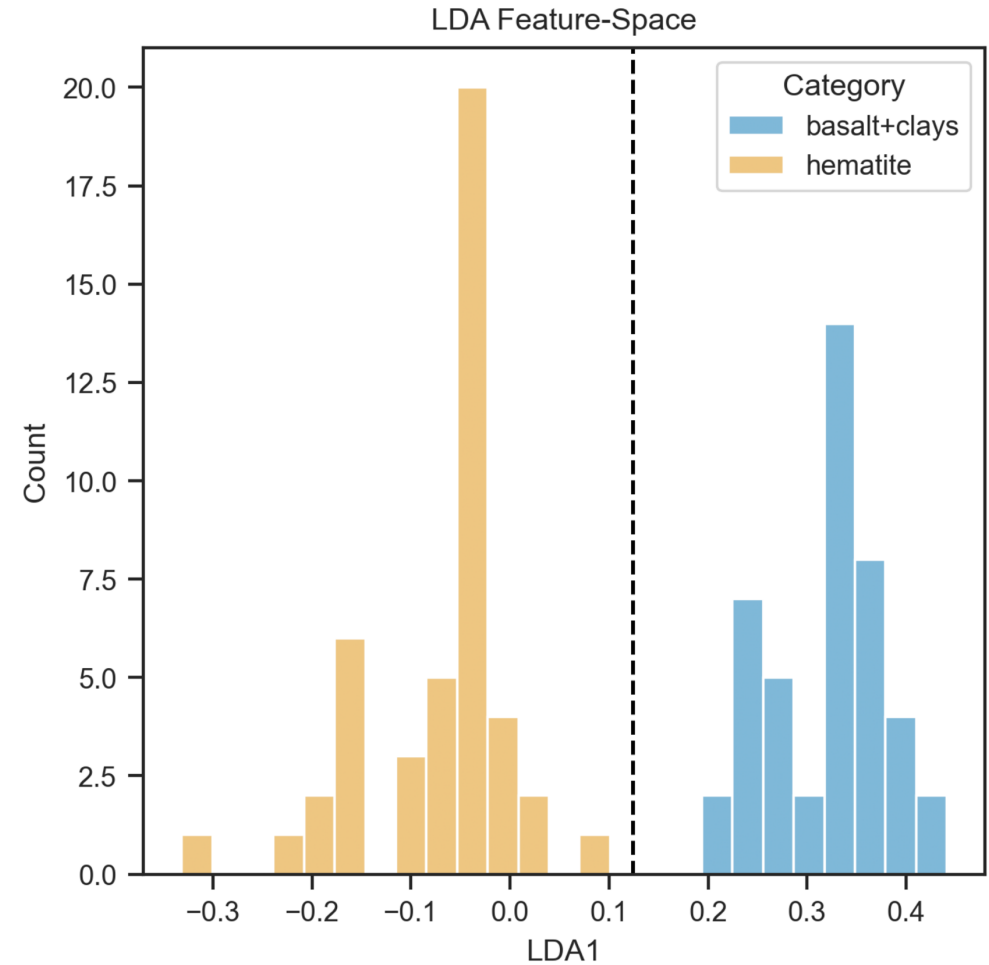
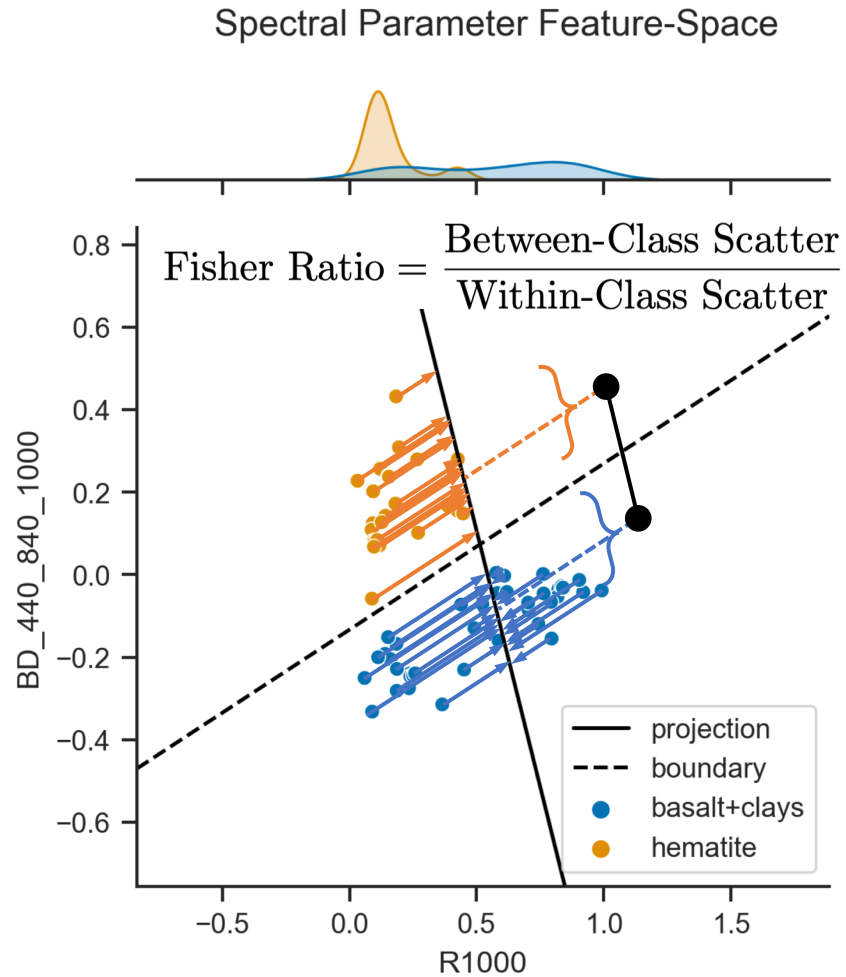
sptk: the Spectral Parameters Toolkit

Linear Discriminant Analysis



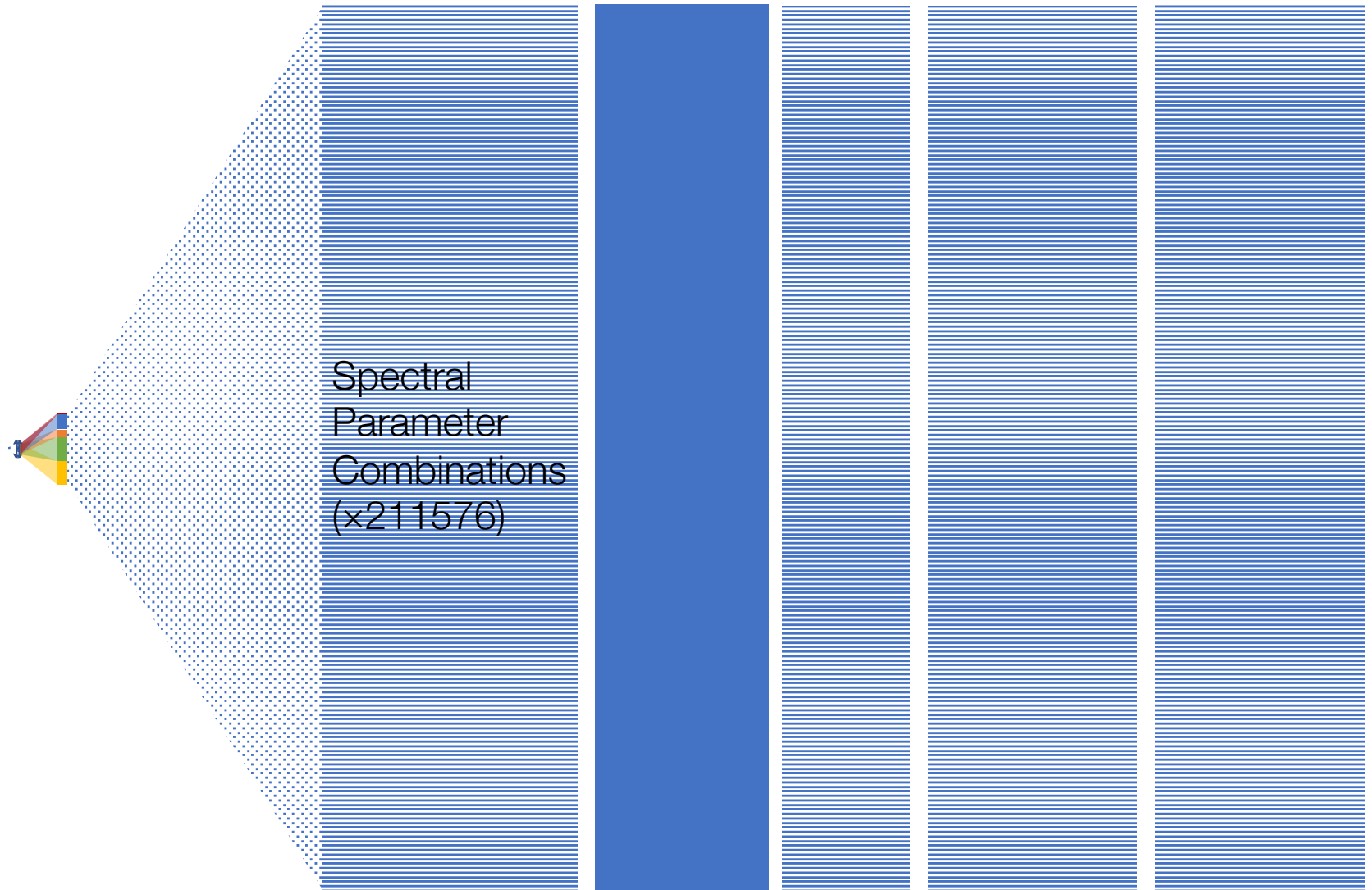
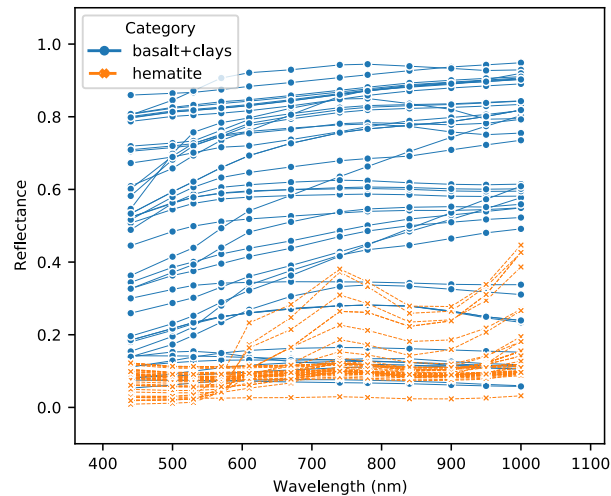
sptk: the Spectral Parameters Toolkit

Linear Discriminant Analysis



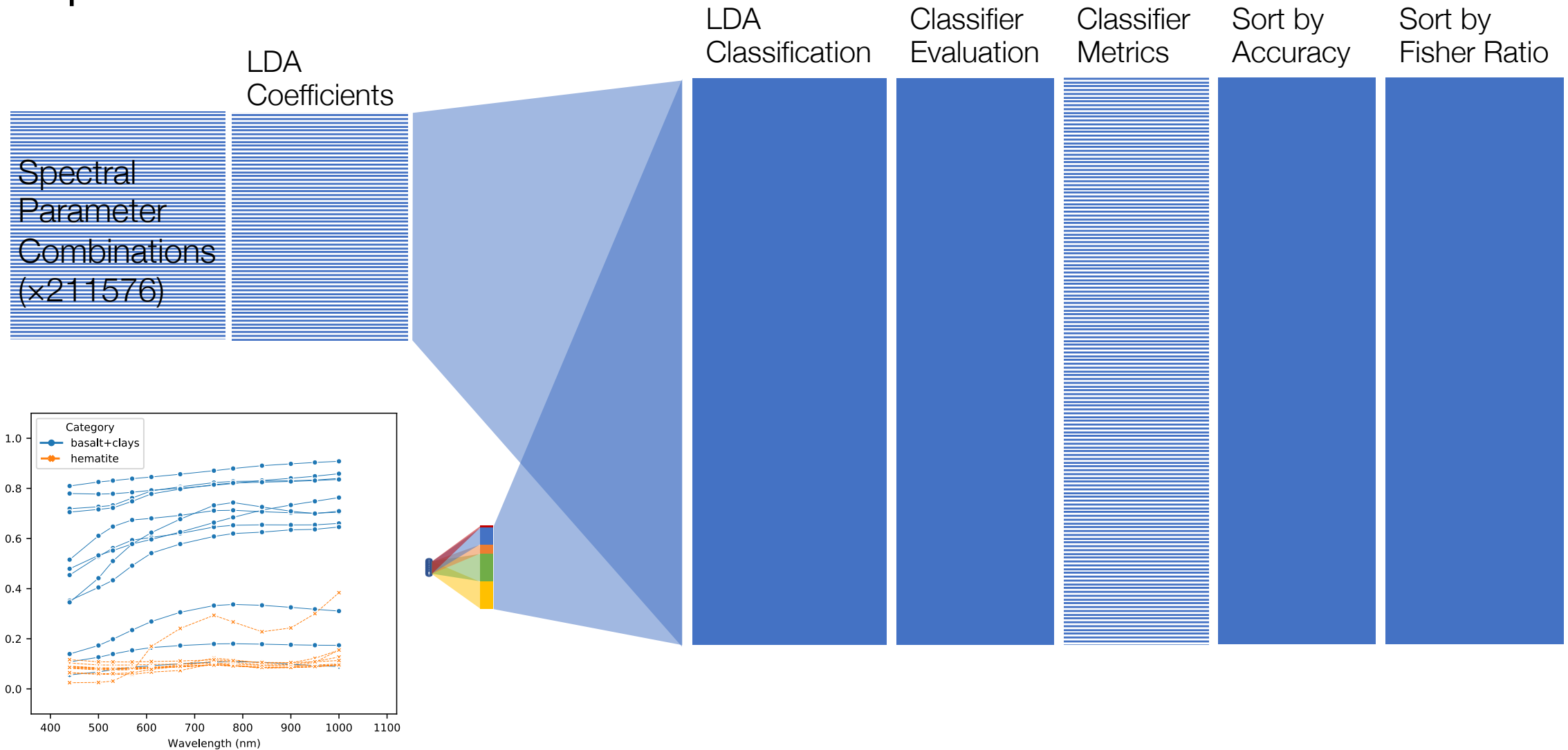
sptk: the Spectral Parameters Toolkit

Pipeline Overview



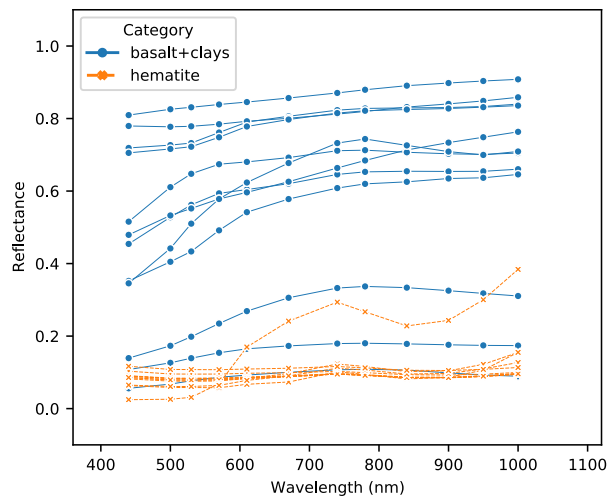
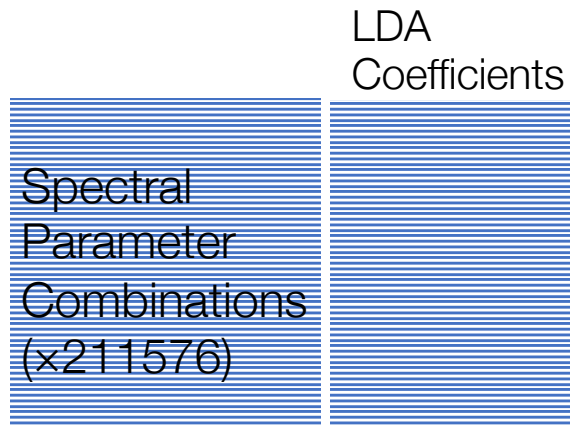
sptk: the Spectral Parameters Toolkit

Pipeline Overview



sptk: the Spectral Parameters Toolkit

Pipeline Overview

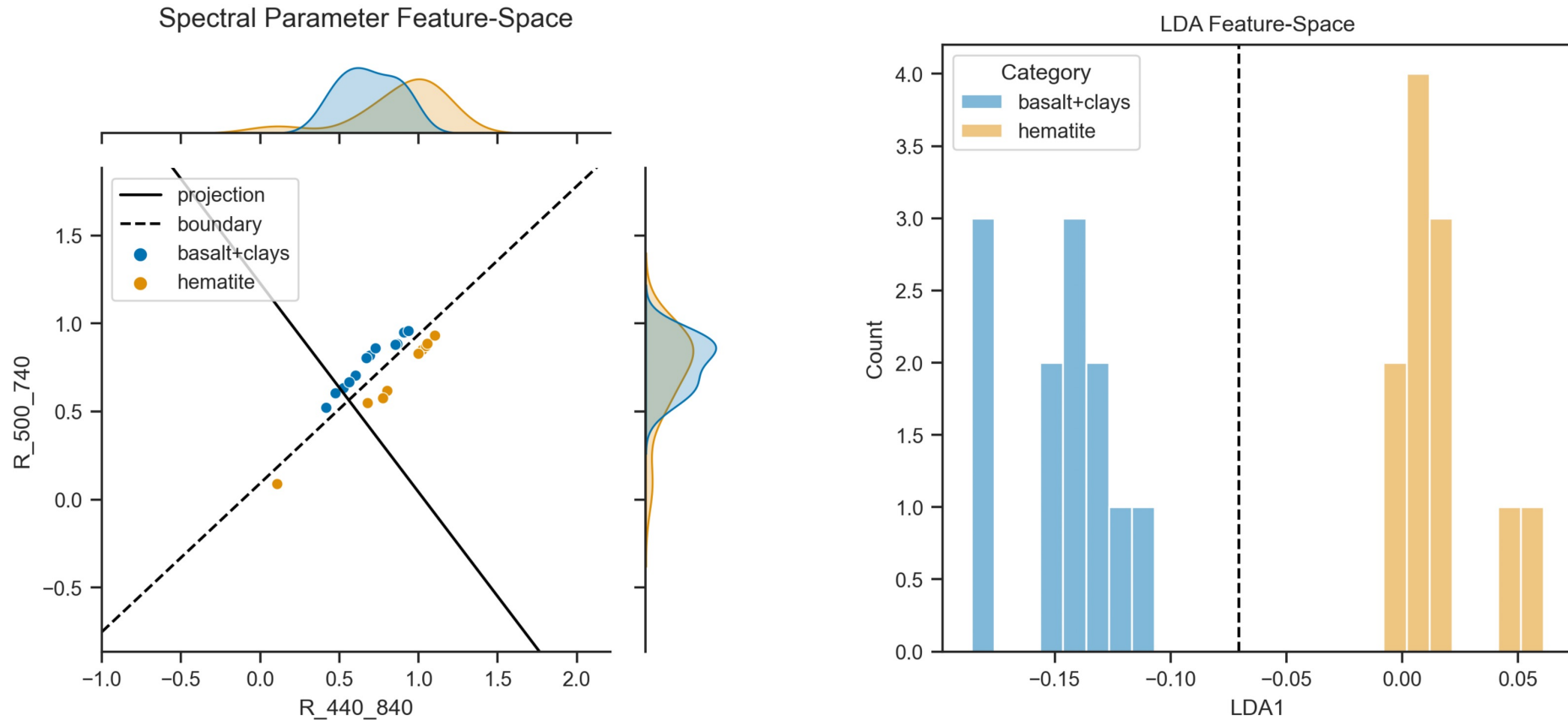


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1	4	1	8.74	R_440_780	R_500_740	G01, G08	G02, G07
2	4	1	7.94	R_440_840	R_500_780	G01, G09	G02, G08
3	4	1	7.76	R_440_840	R_500_740	G01, G09	G02, G07
4	4	1	7.02	R_440_840	R_530_740	G01, G09	G03, G07
5	3	1	6.71	R_440_740	R_500_740	G01, G07	G02, G07
6	3	1	6.63	R_440_780	R_500_780	G01, G08	G02, G08
7	4	1	6.52	R_440_840	R_530_780	G01, G09	G03, G08
8	3	1	6.43	R_440_670	R_500_670	G01, G06	G02, G06
9	3	1	6.32	R_440_840	R_500_840	G01, G09	G02, G09
10	3	1	5.96	R_440_610	R_500_610	G01, G05	G02, G05
11	4	1	5.90	R_440_840	R_570_740	G01, G09	G04, G07
12	4	1	5.89	R_440_780	R_530_740	G01, G08	G03, G07
13	3	1	5.66	R_440_900	R_500_900	G01, G10	G02, G10
14	3	1	5.50	R_440_570	R_500_570	G01, G04	G02, G04
15	3	1	5.06	R_440_950	R_500_950	G01, G11	G02, G11
16	4	1	5.04	R_440_840	R_570_780	G01, G09	G04, G08
17	4	1	5.00	R1000	SH_740_780_950	G12	G07, G08, G11
...

sptk: the Spectral Parameters Toolkit

Results – Hematite vs Basalts & Clays

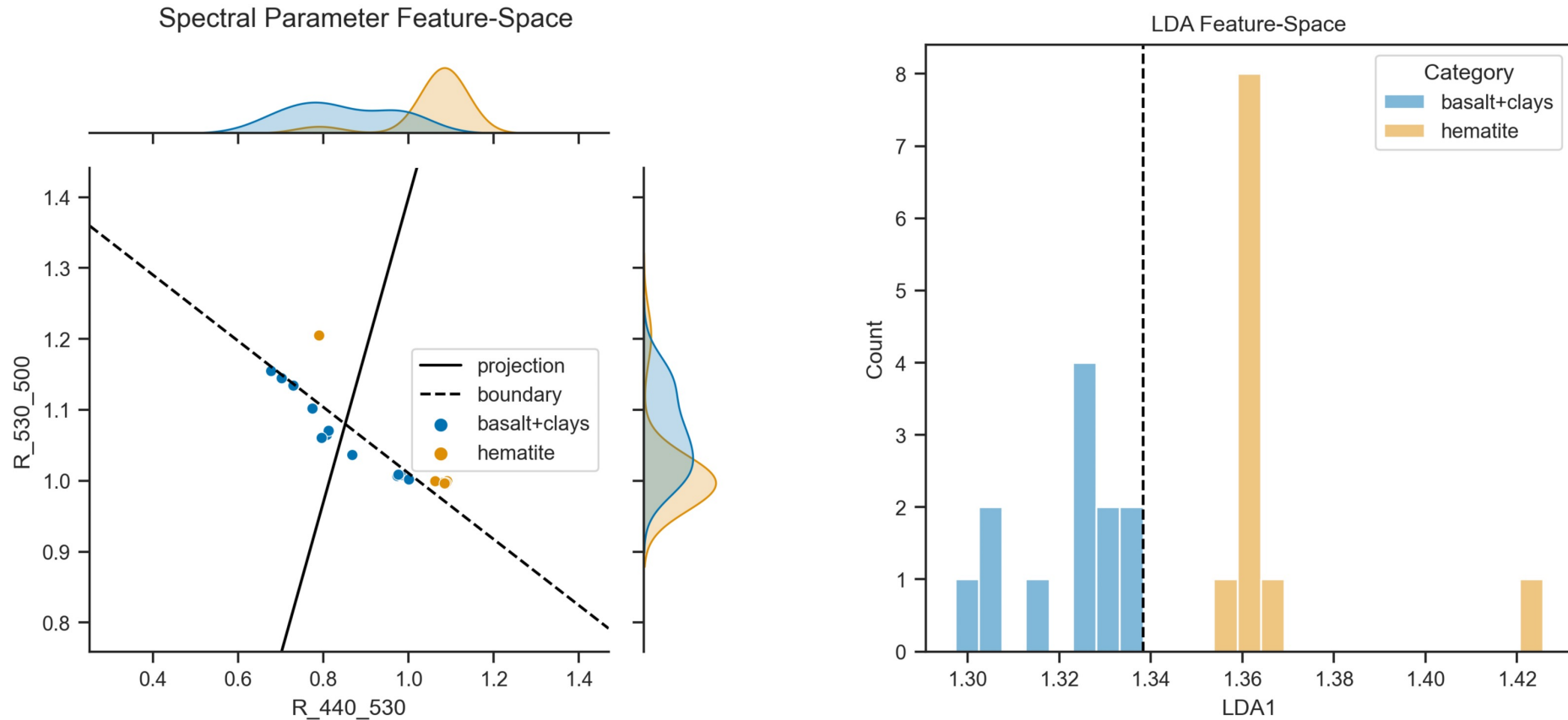
Rank 1, Accuracy 1.0, #Filters 4: G02, G07, G01, G09, SPs: R_500_740, R_440_840, test data



sptk: the Spectral Parameters Toolkit

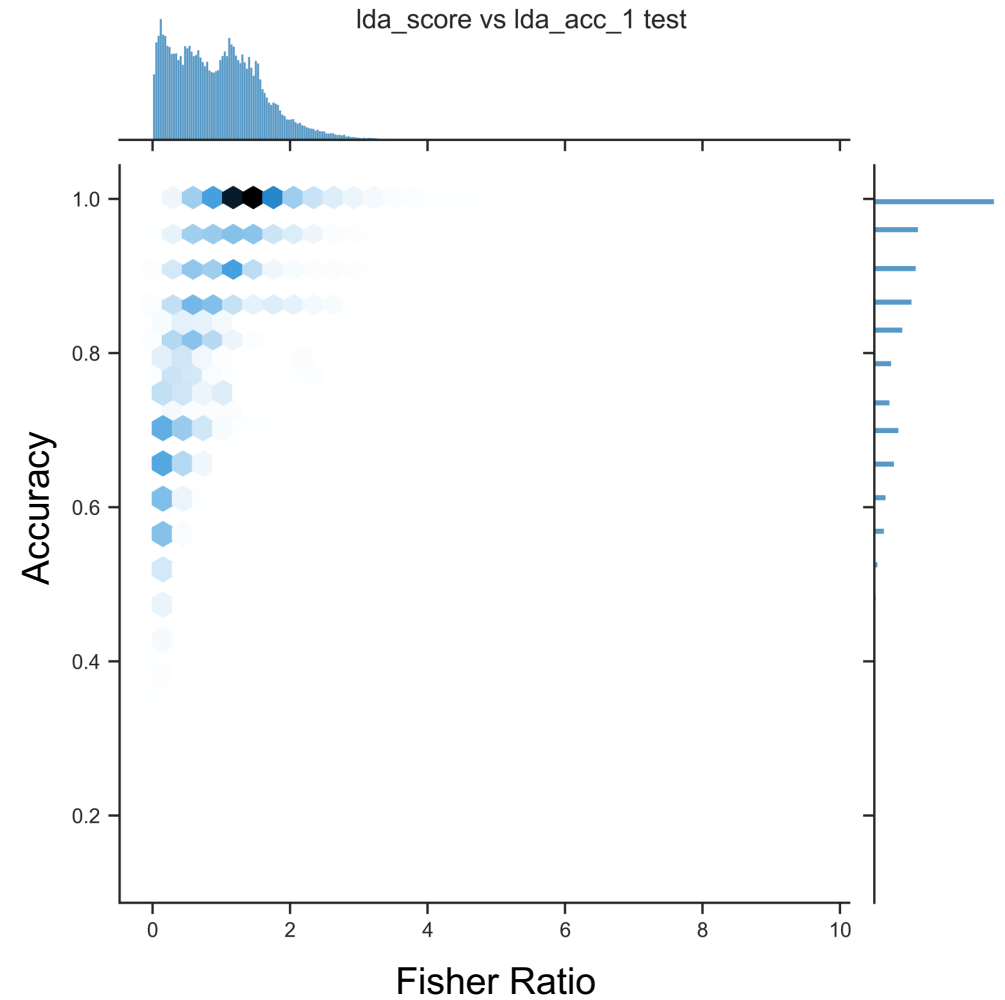
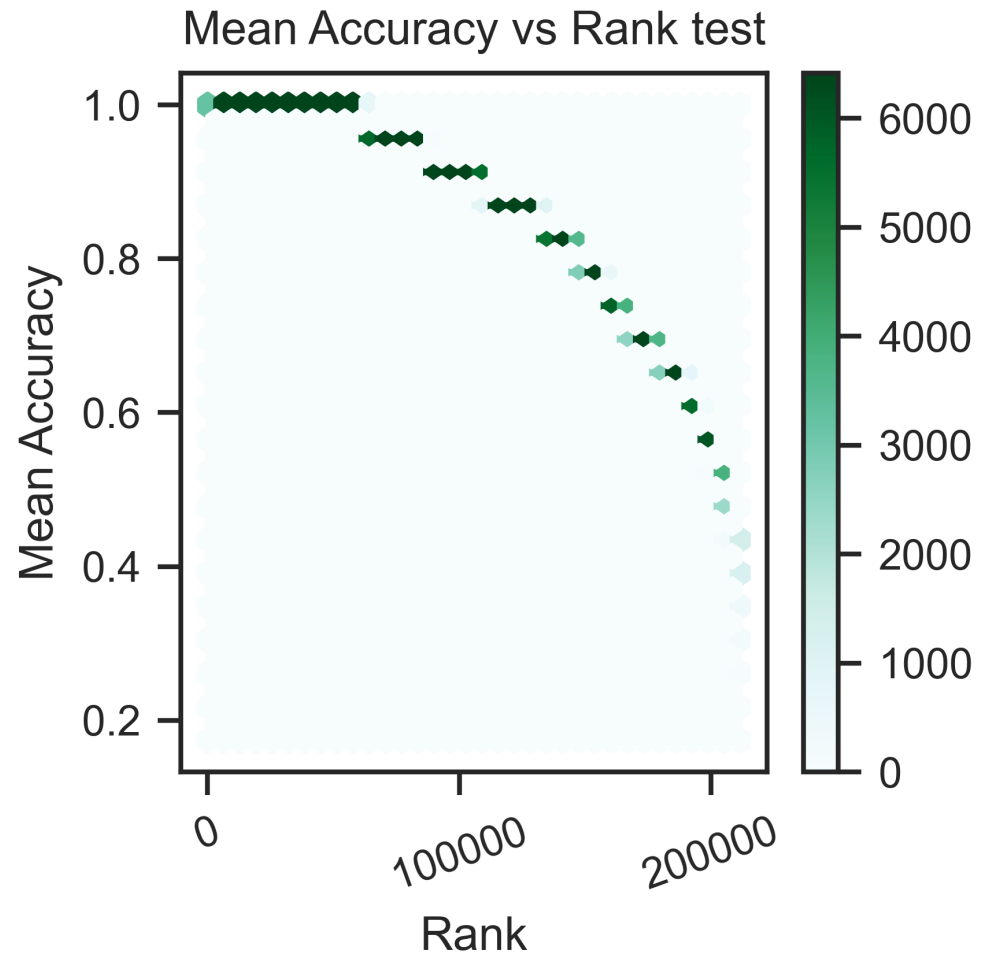
Results – Hematite vs Basalts & Clays

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



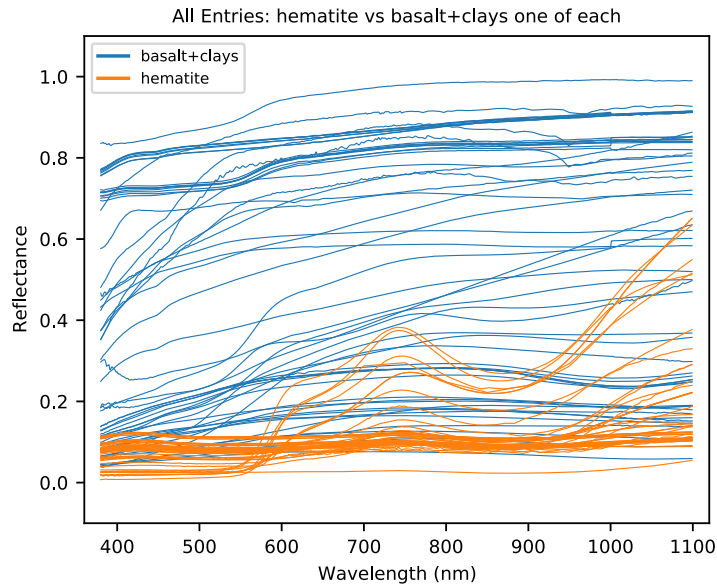
sptk: the Spectral Parameters Toolkit

Results – Hematite vs Basalts & Clays

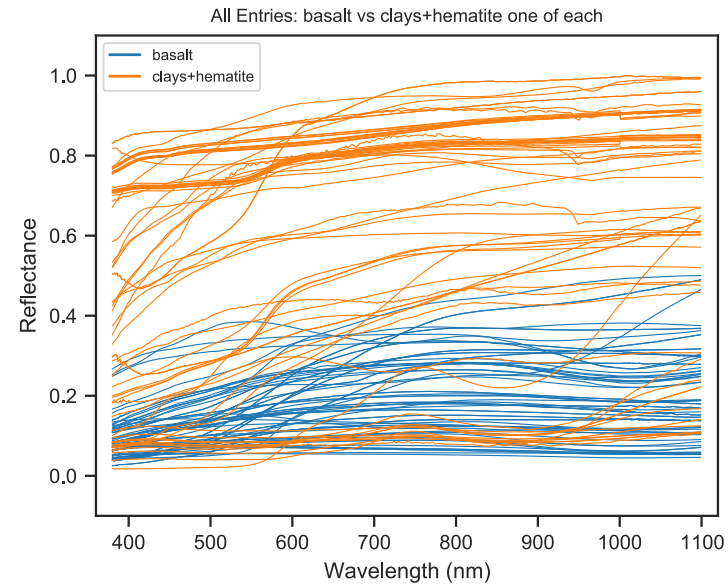


sptk: the Spectral Parameters Toolkit

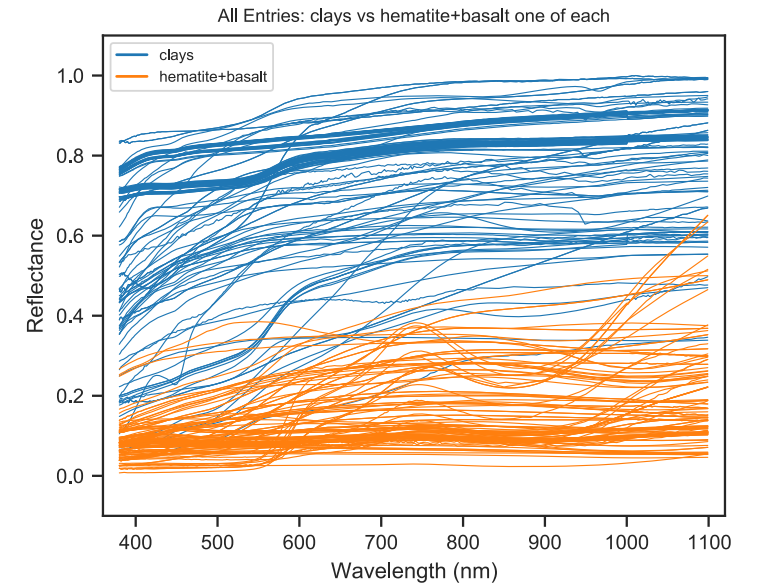
Multi-class separation



Hematite
VS
Clays & Basalts



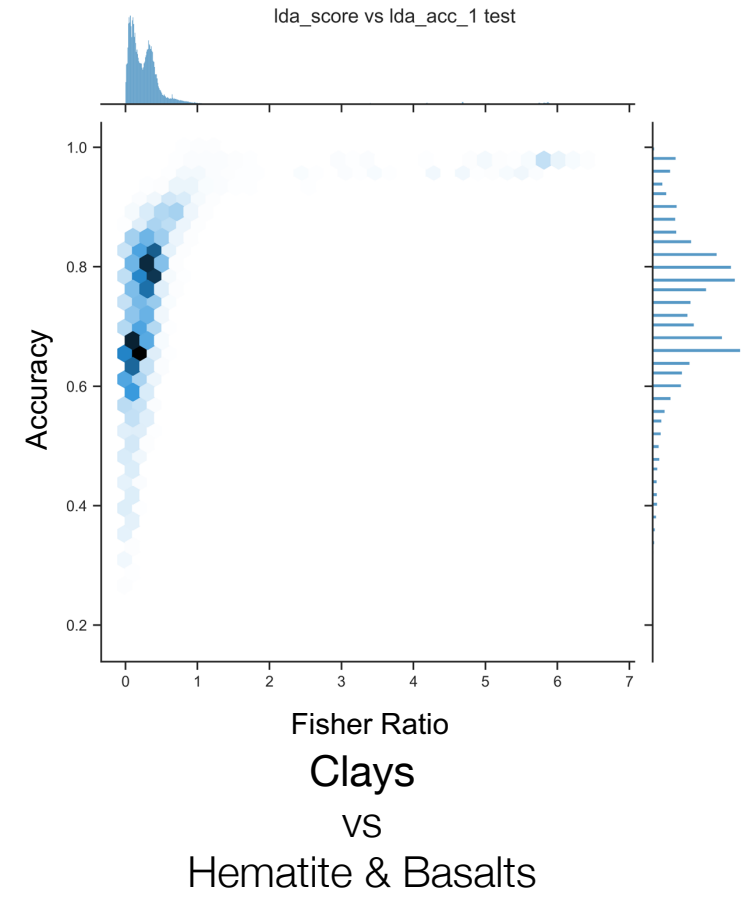
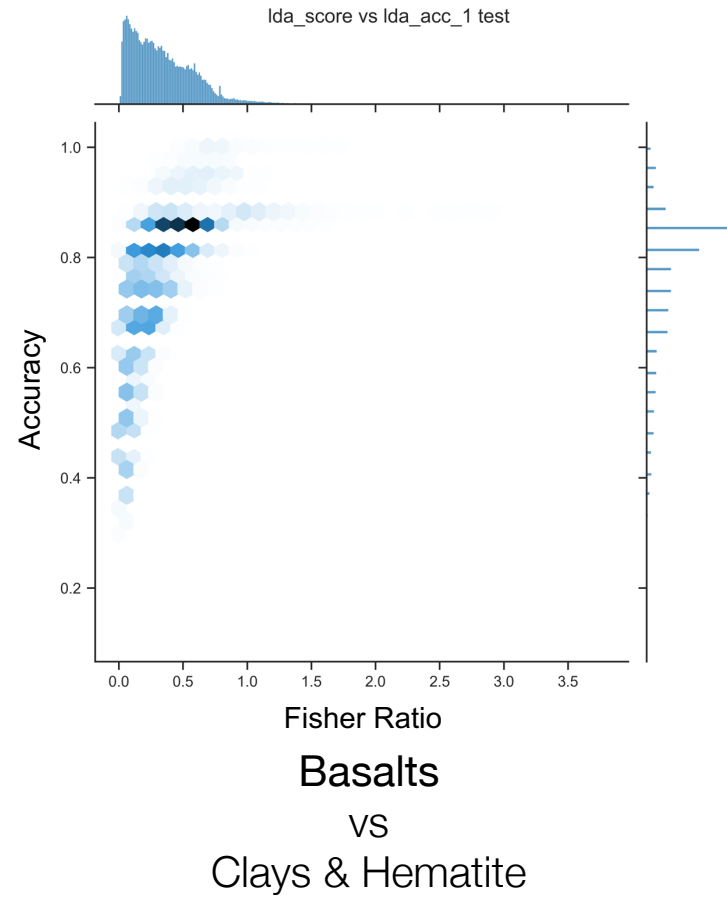
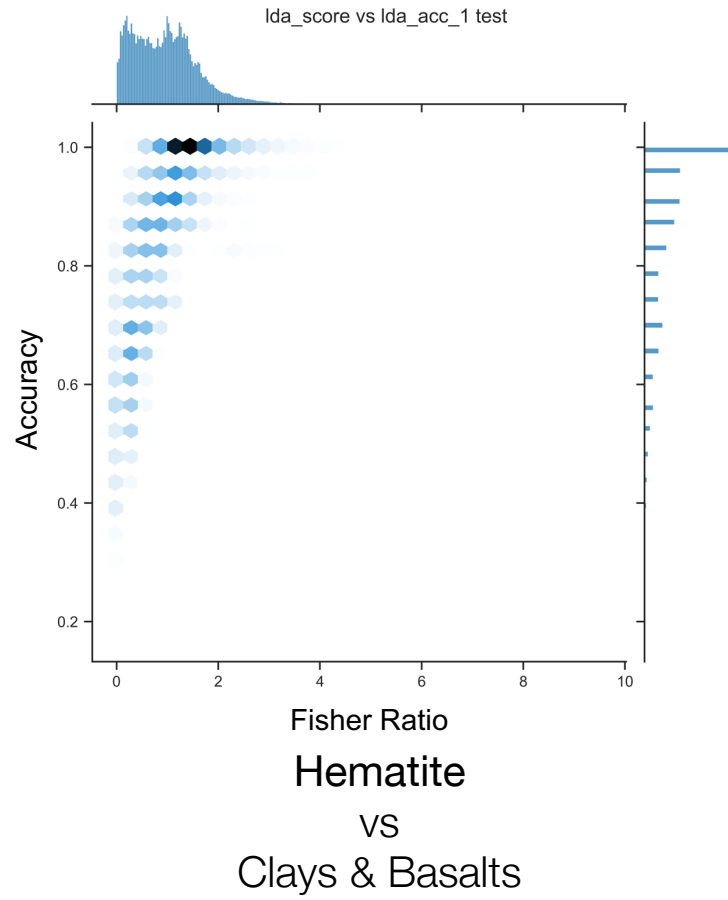
Basalts
VS
Clays & Hematite



Clays
VS
Hematite & Basalts

sptk: the Spectral Parameters Toolkit

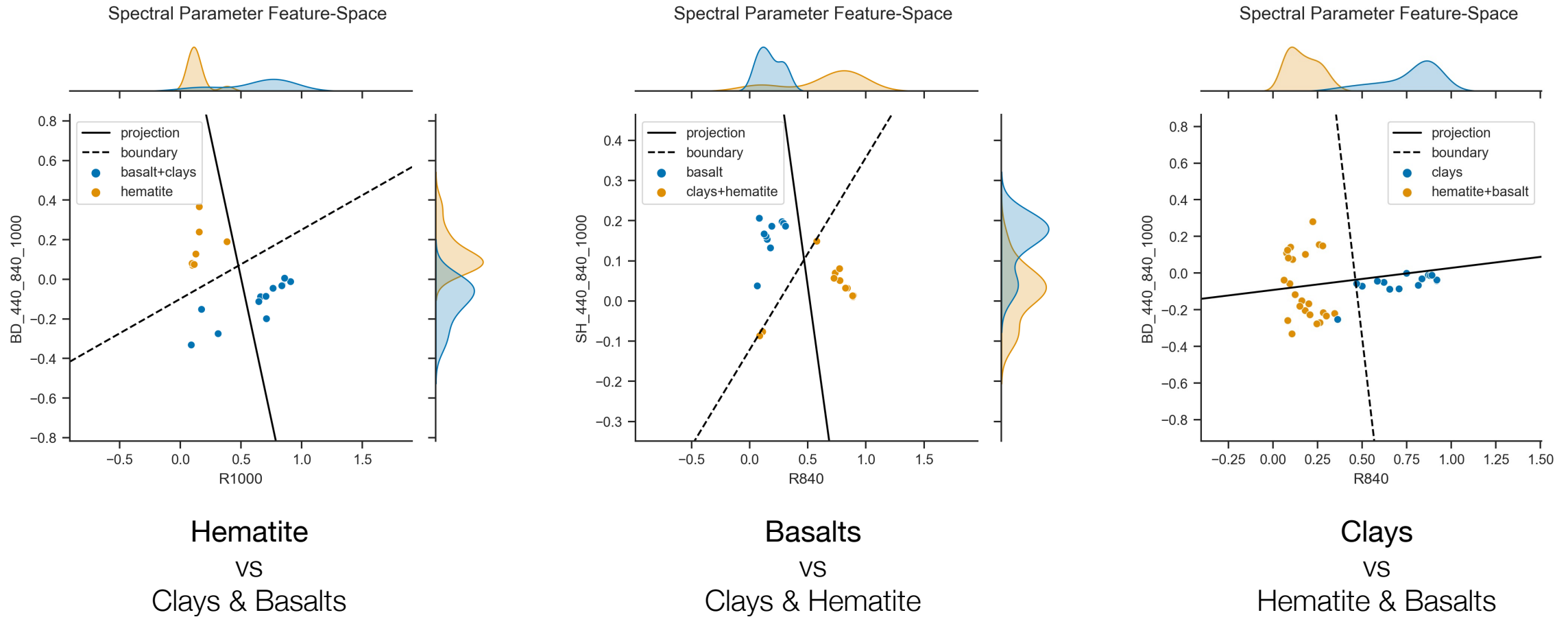
Multi-class separation

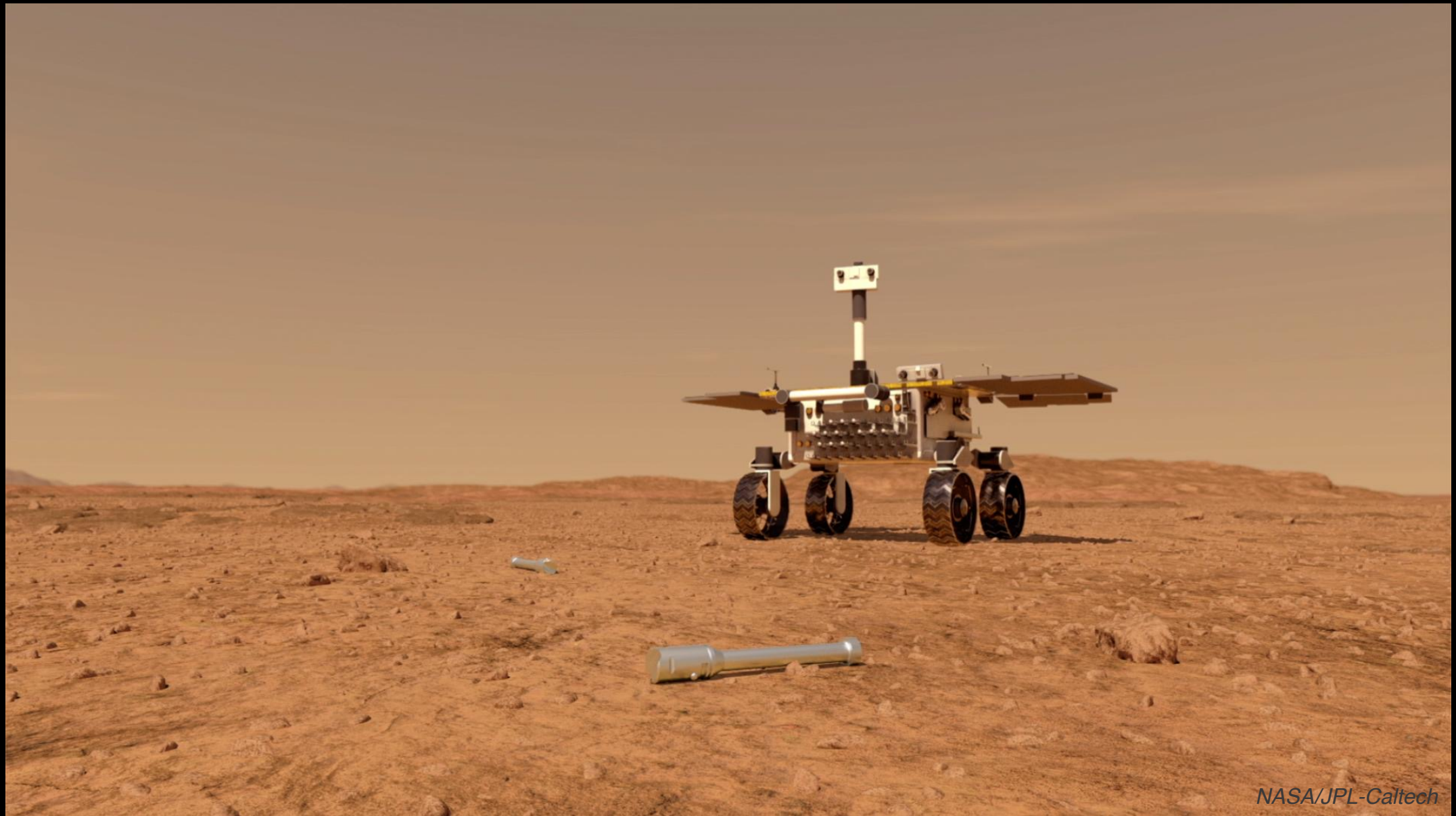


sptk: the Spectral Parameters Toolkit

Multi-class separation

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





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

