Interactive Discovery of New Phenomena in Martian Point Spectra and Hyperspectral Data Sets

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Principal Component Analysis

ChemCam calibration data set (n=110, d=6143)

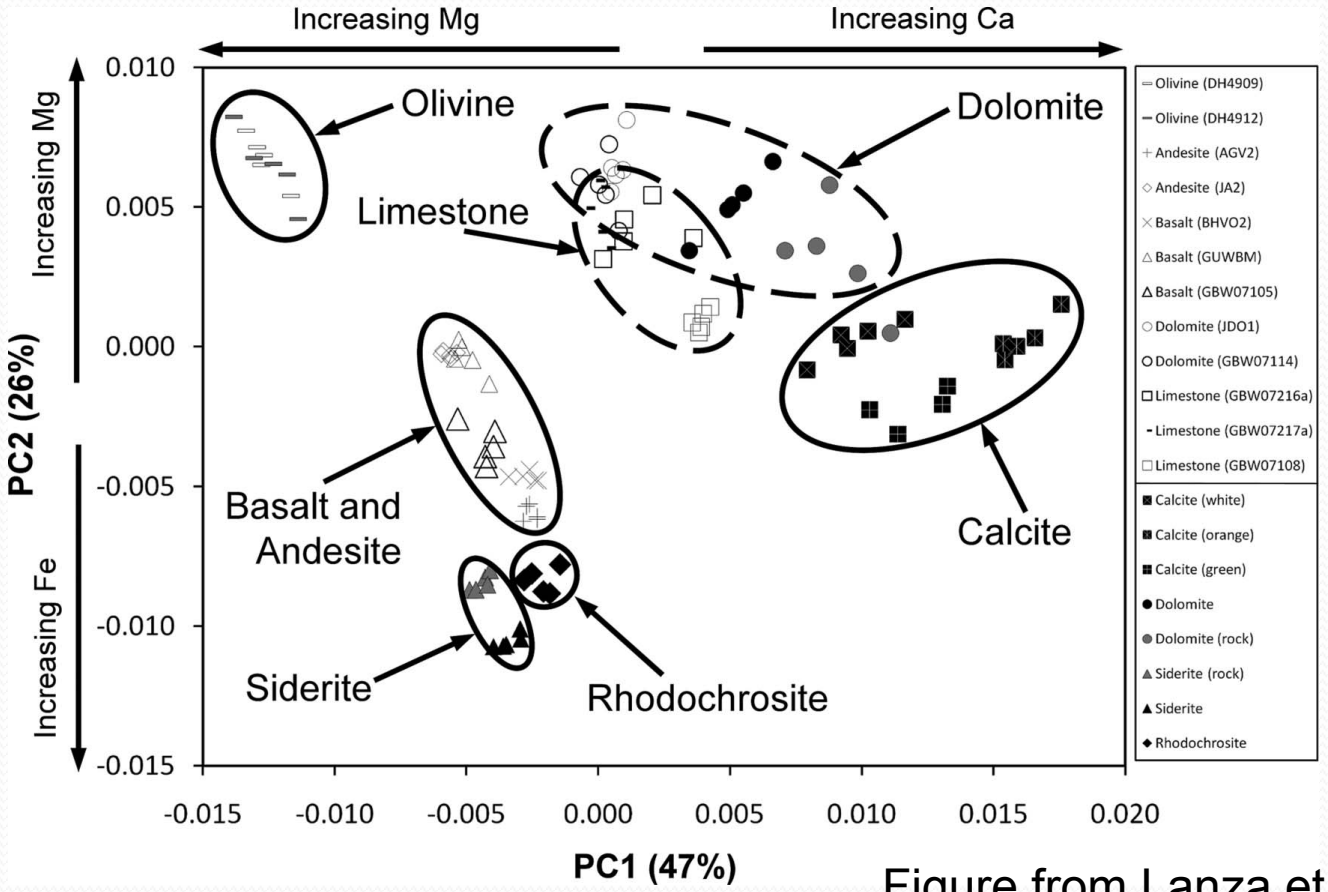
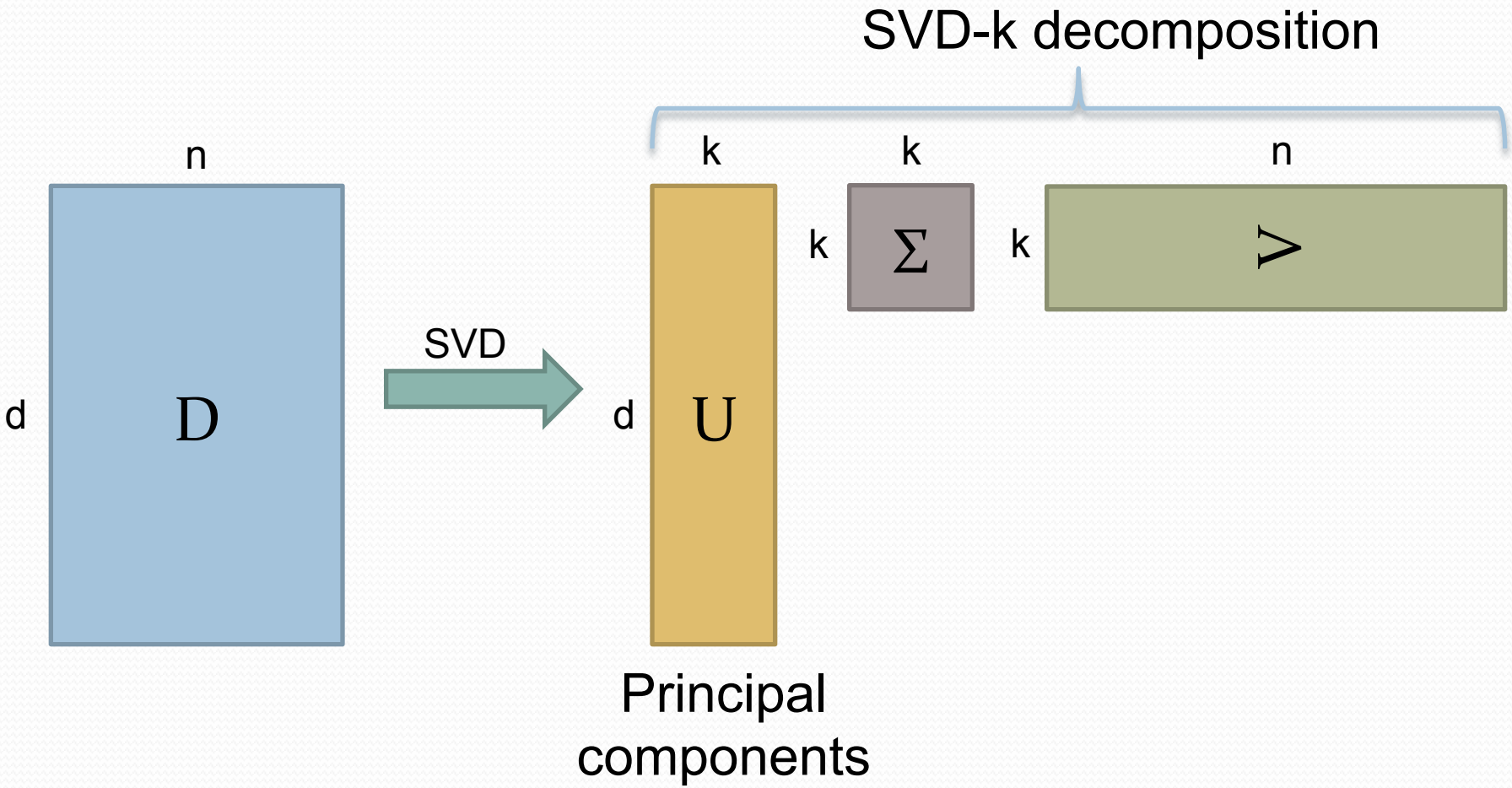
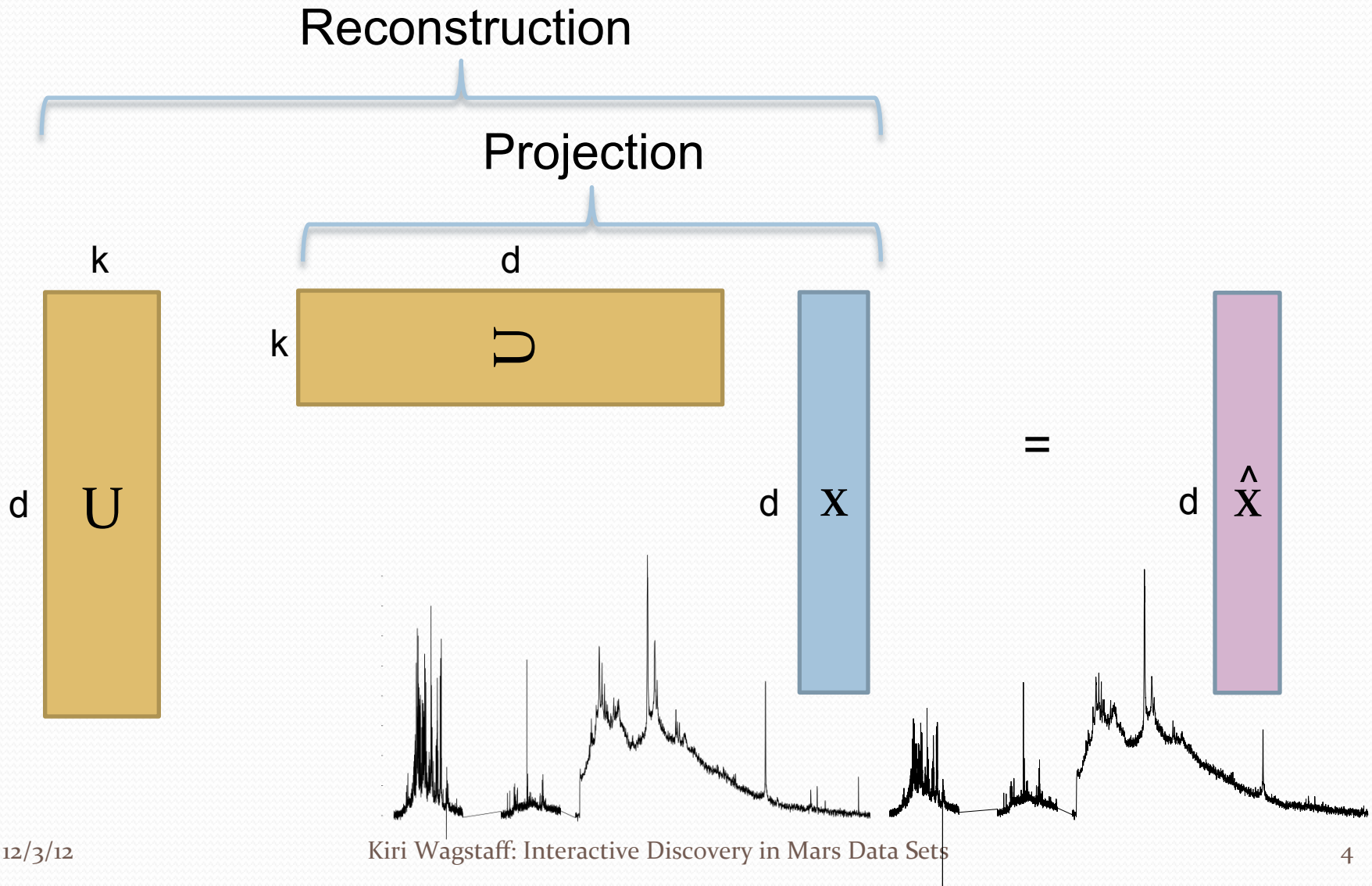


Figure from Lanza et al., 2010

SVD-k truncates PCA to k components



PCs can be used to "explain" data



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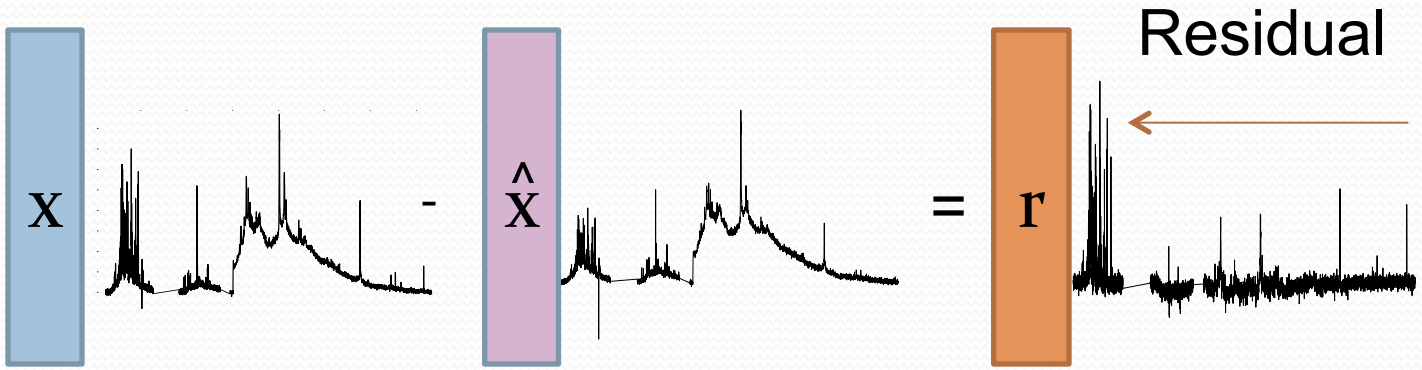
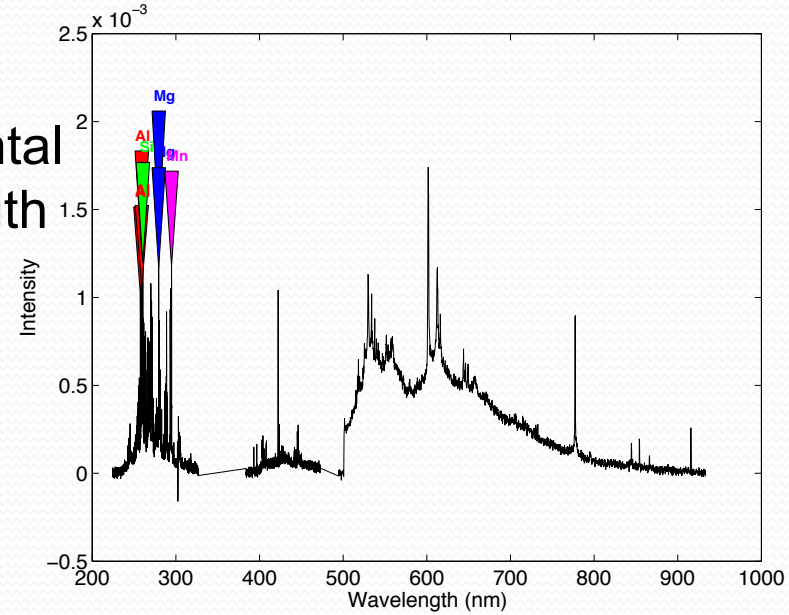
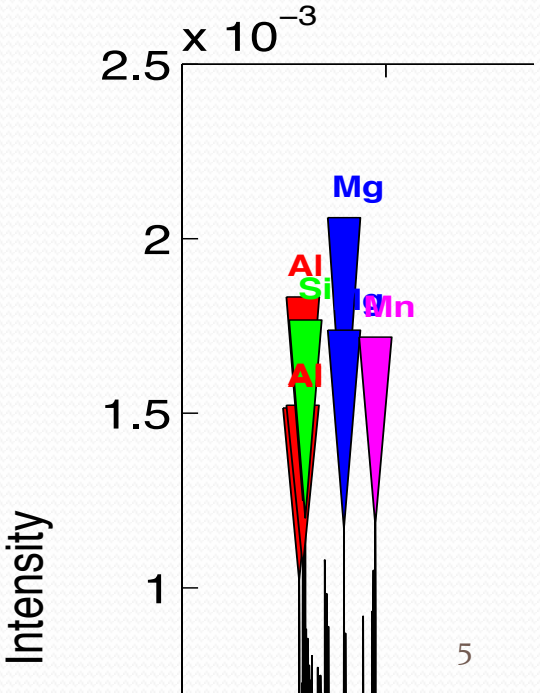


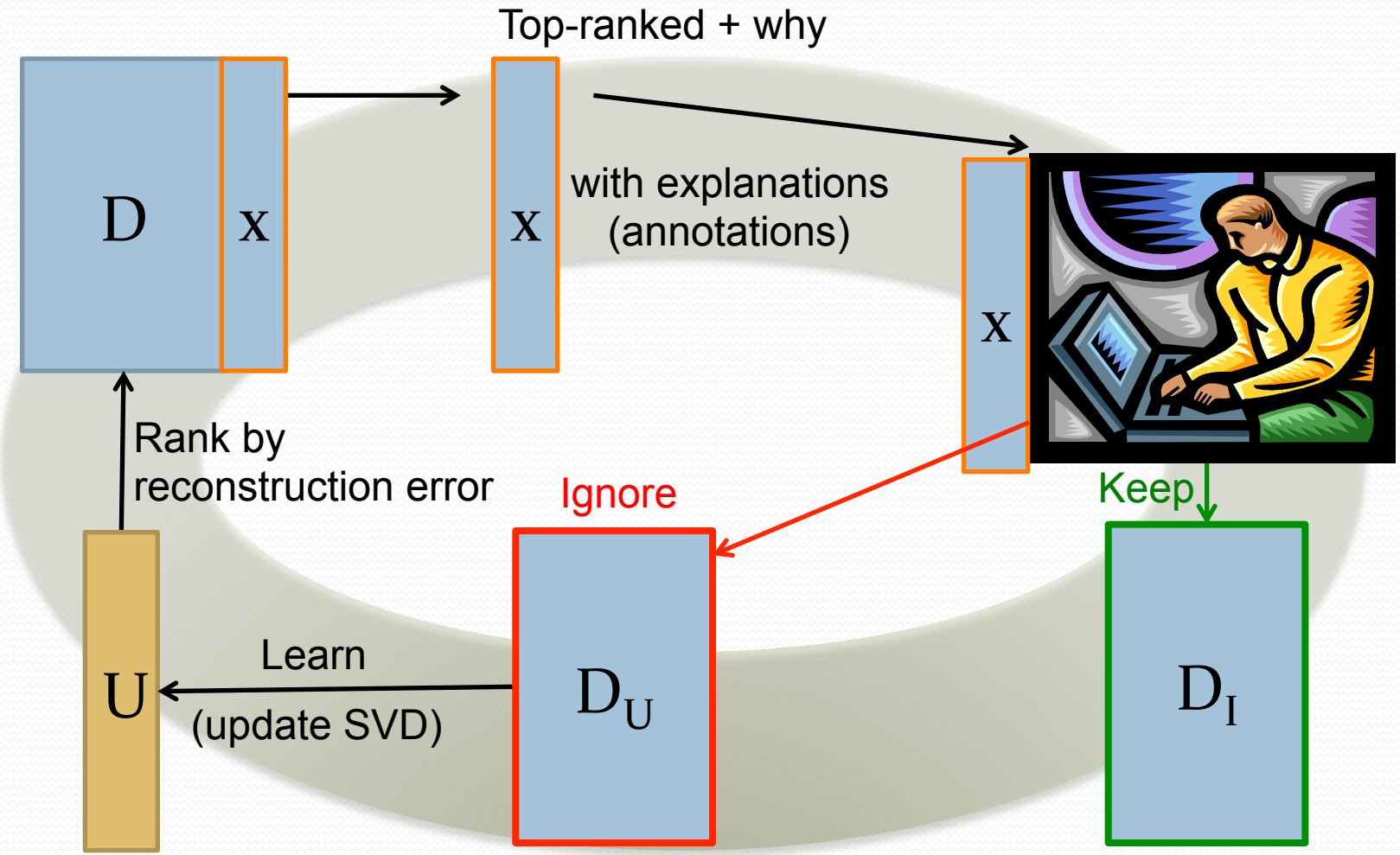
SVD “model” could not reconstruct / explain

Annotate elemental emission lines with high residuals:



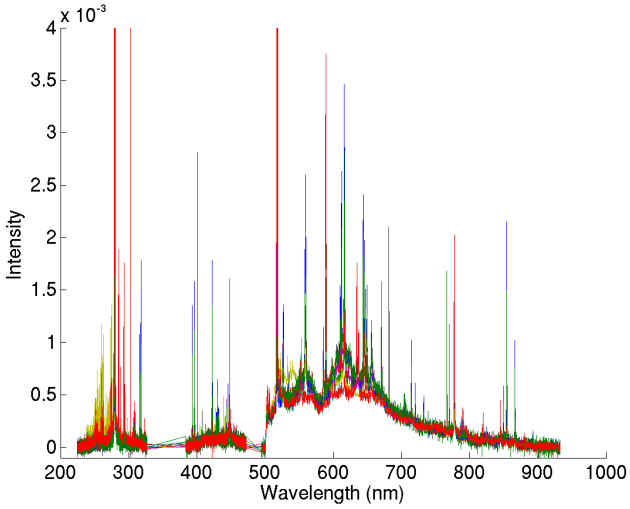


DEMUD: Discovery via Eigenbasis Modeling of Uninteresting Data

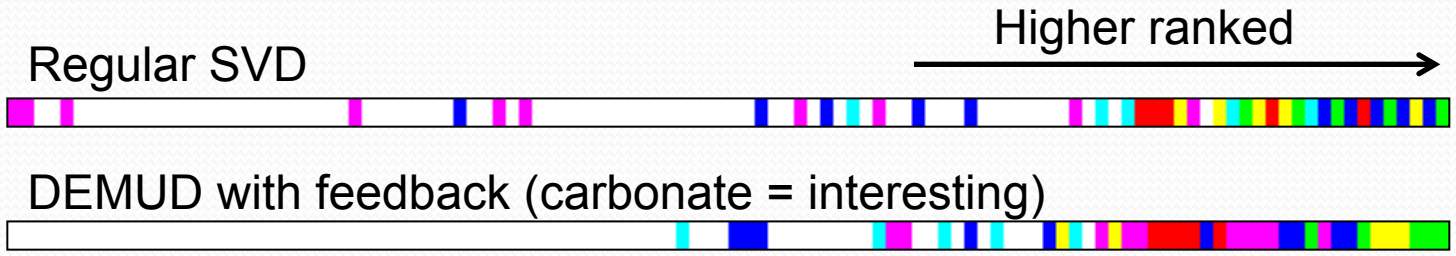


ChemCam: Carbonates

- ChemCam: LIBS instrument on MSL
- Calibration data set:
  70 lab standards + 40 carbonates
  - 6143 features (bands) observed with lab spectrometer (not ChemCam)
  - K (8) captures 90% variance



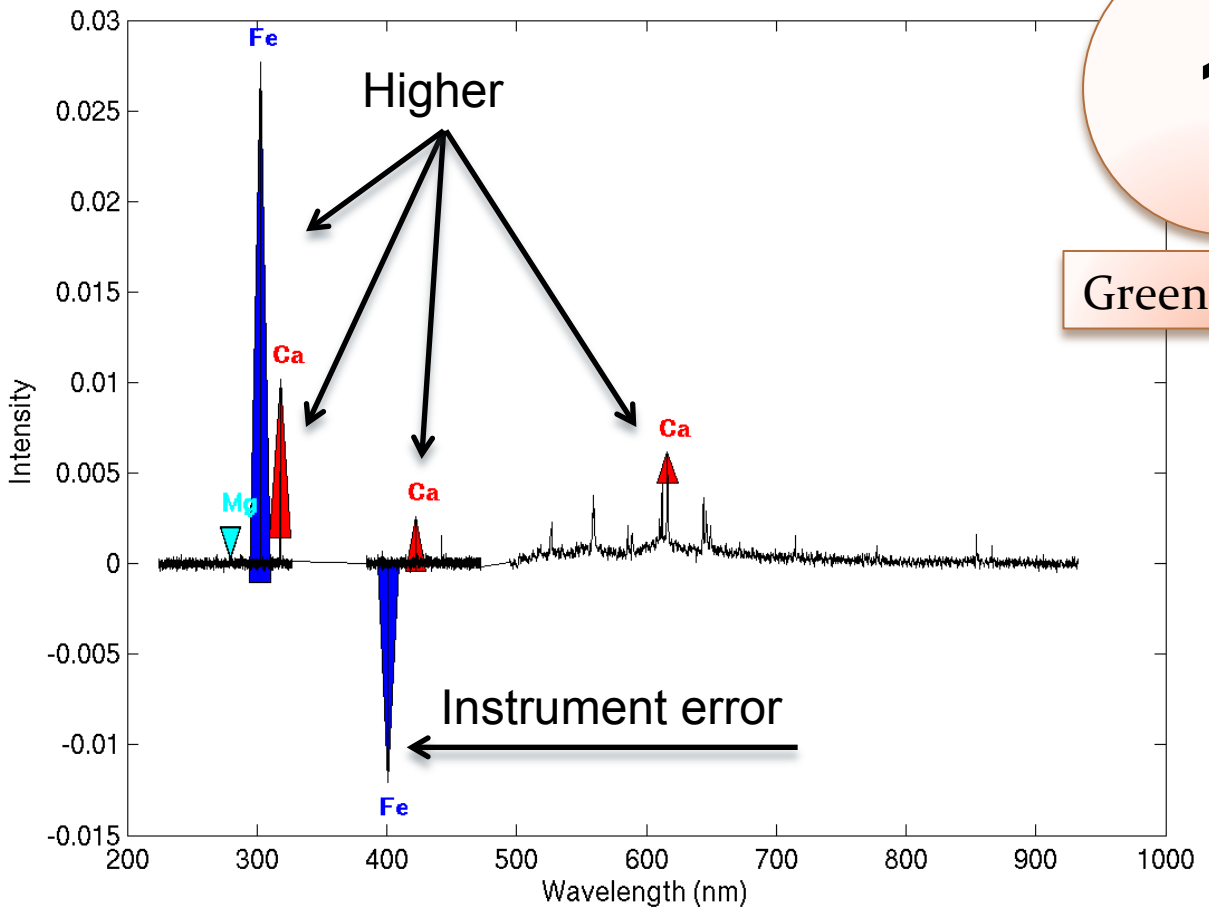
Calcite
Green calcite
Orange calcite
Dolomite
Rhodochrosite
Siderite



ChemCam: First selection

Higher than expected

Lower than expected



1

Green Calcite

Legend

Ca

Fe

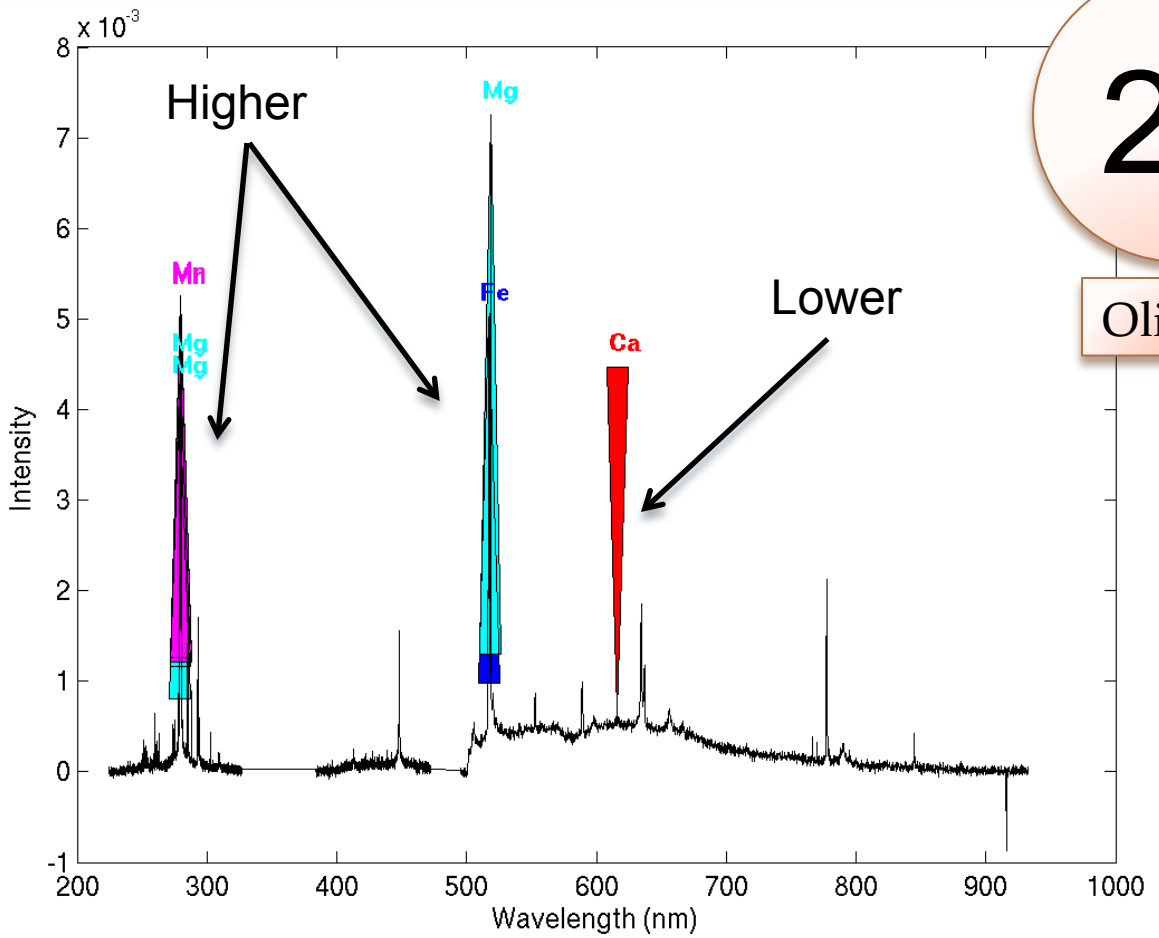
Mg

Mn

ChemCam: First non-carbonate

Higher than expected

Lower than expected



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Olivine

Legend

Ca

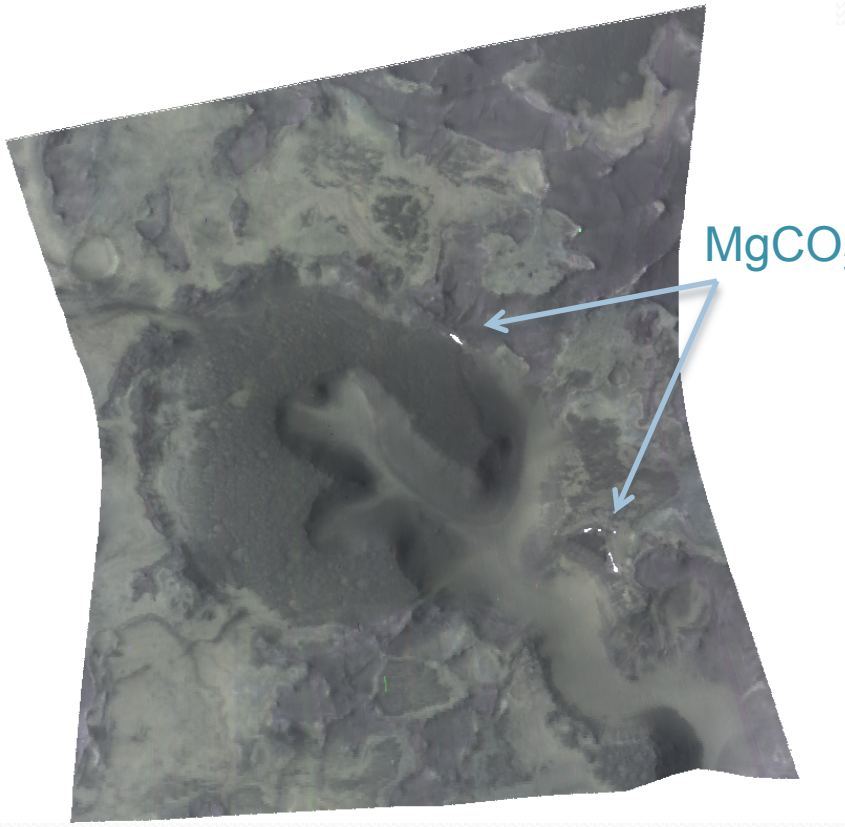
Fe

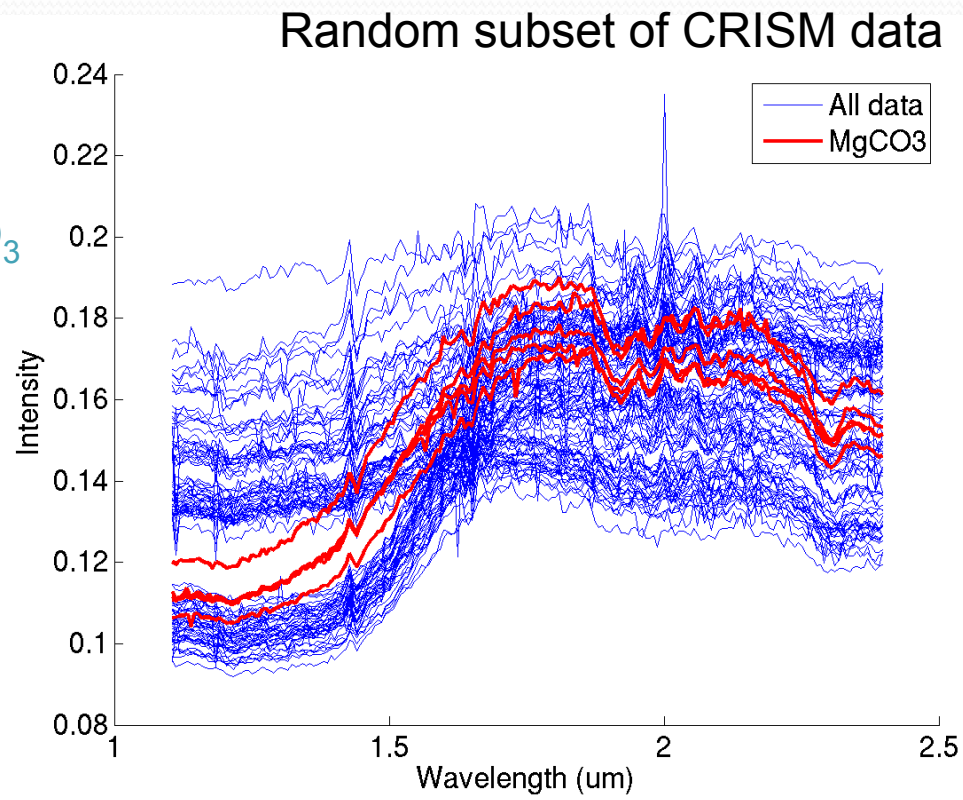
Mg

Mn

CRISM: Magnesite discovery

- Magnesite ($MgCO_3$): possible groundwater deposit
- CRISM data: 0.364 to 3.92 μm, 197 bands
- Nili Fossae: only 17 of 15,400 items match



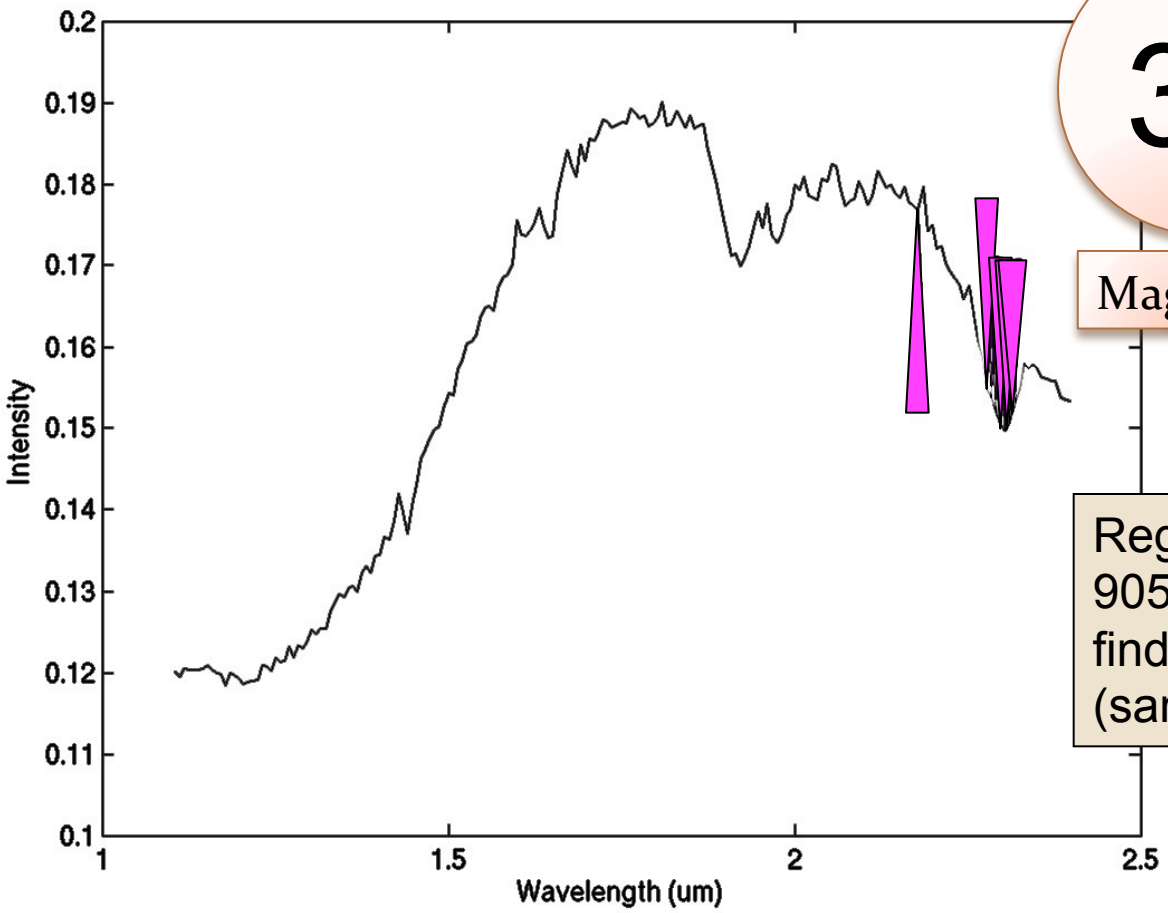


Data from Mars Reconnaissance Orbiter/CRISM

CRISM: First magnesite

Higher than expected

Lower than expected



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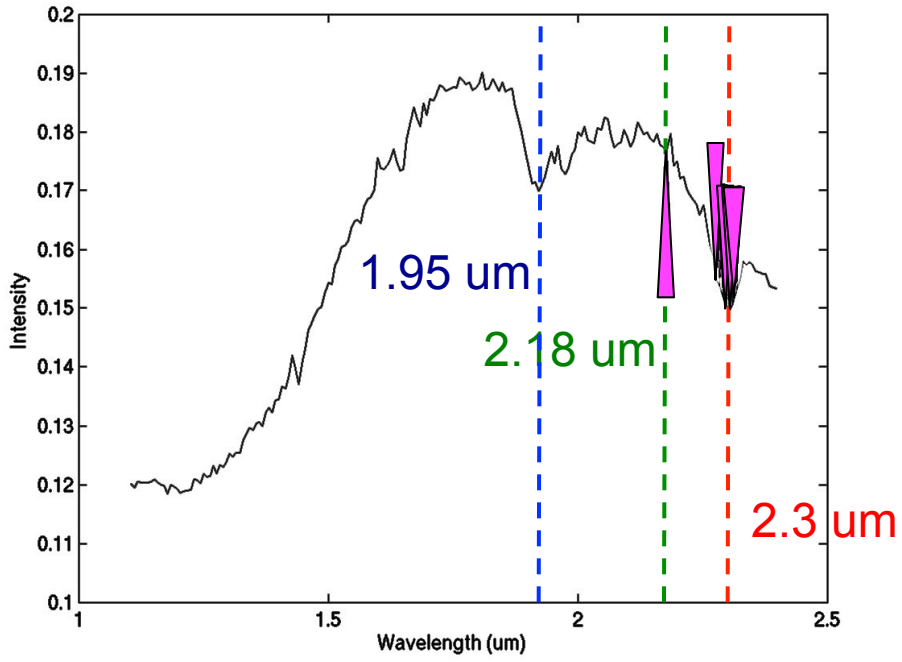
Magnesite

Regular SVD:
905 queries to find 1st magnesite (same as random)

Similar to Gusev findings

Nili Fossae with DEMUD explanations



Gusev: Mg-rich member (~magnesite), plus 1.95-µm hydrous silica mixture?

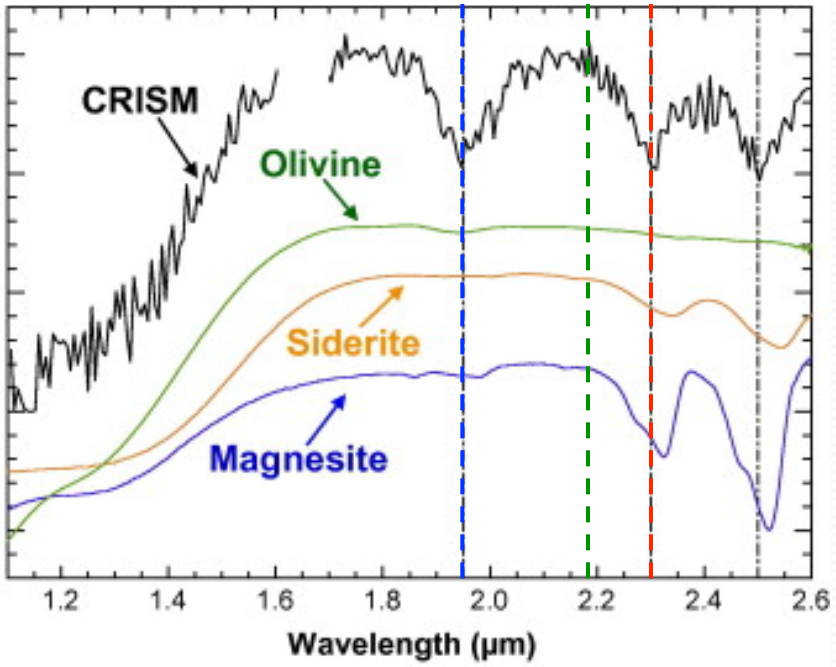


Figure from Carter & Poulet, 2012

Summary

- DEMUD: Interactive discovery in large data sets
  - Adapts to individual feedback / priorities
  - Provides explanations for spectra of interest
- ChemCam calibration data results
  - Found carbonates in half the queries needed by SVD
  - Explanations:
    - Carbonates: ↑Ca, ↓Mg; olivine: ↑Mn, ↑Mg, ↑Fe, ↓Ca
- CRISM: found potential magnesite with just 36 queries of 15,400 candidates and no previous training

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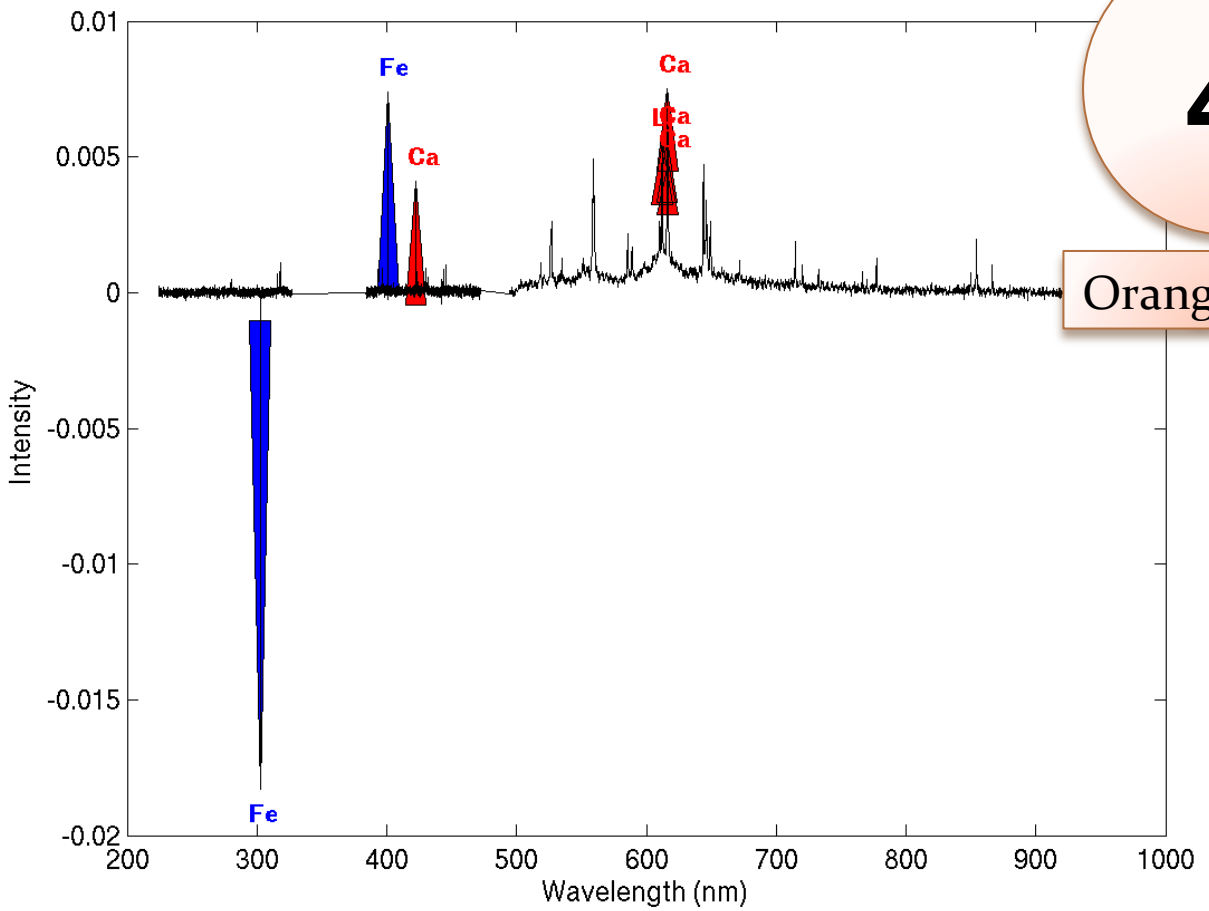
Backup Slides

ChemCam: Explanations

Higher than expected

Lower than expected



4

Orange Calcite

Legend

Ca

Fe

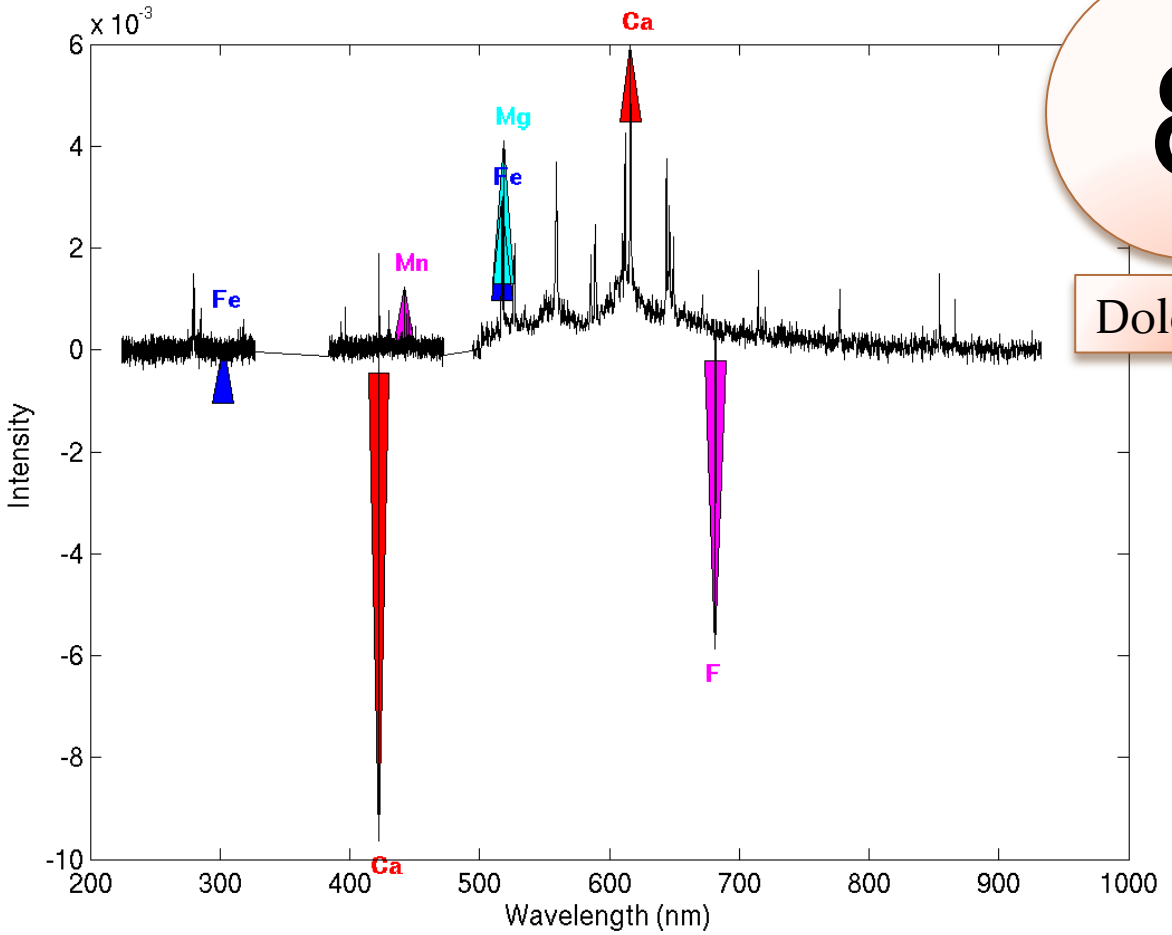
Mg

Mn

ChemCam: Explanations

Higher than expected

Lower than expected



8

Dolomite

Legend

Ca

Fe

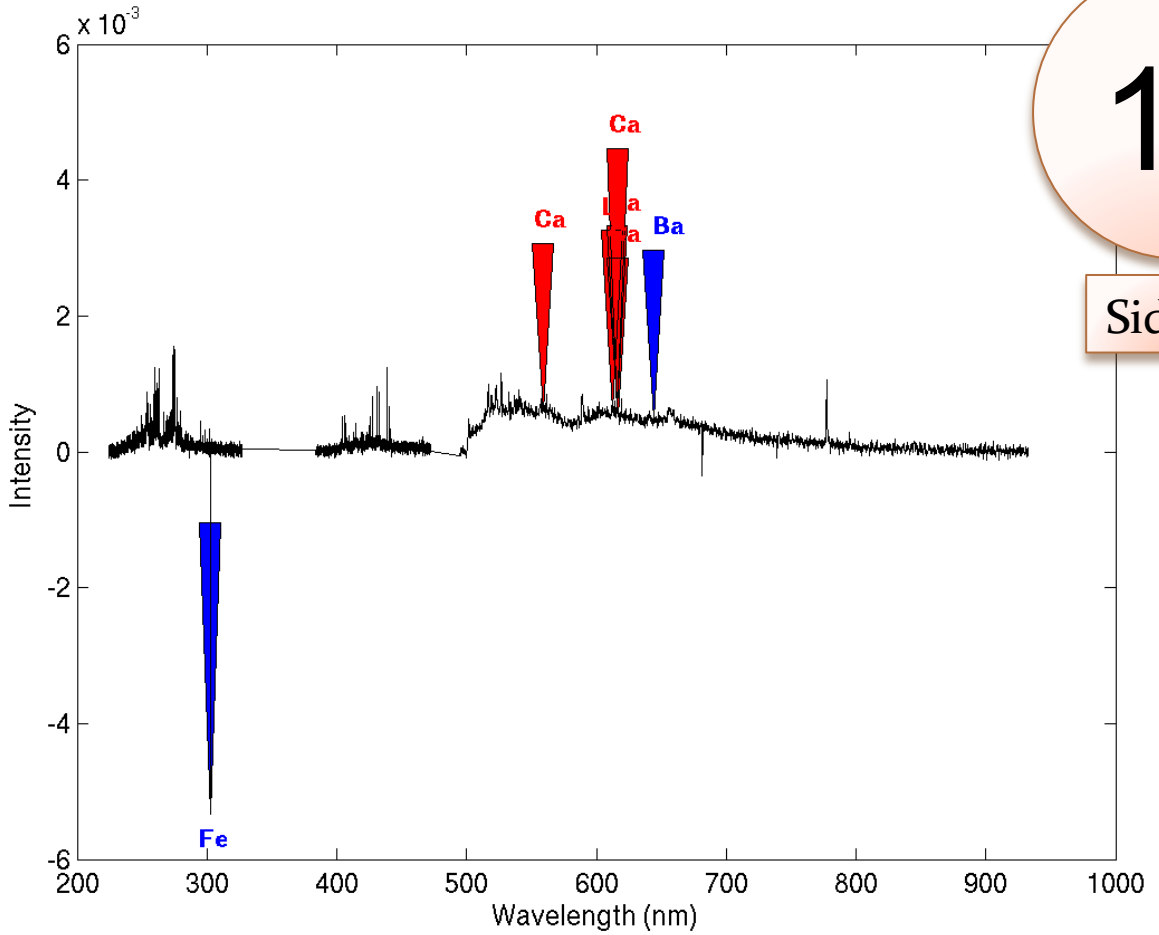
Mg

Mn

ChemCam: Explanations

Higher than expected

Lower than expected



10

Siderite

Legend

Ca

Fe

Mg

Mn

CRISM: Magnesite Discovery