Analysis of Landslide, Debris Flow and Flood Hazards Surrounding the Salton Sea, Southern California: Results Using HyspIRI Preparatory Imagery, Field Spectral Data and Observations

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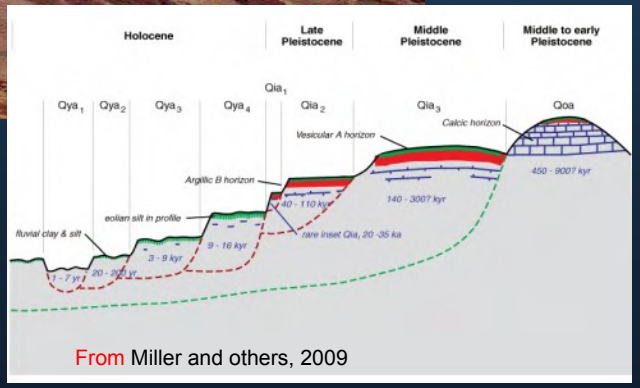
Desert Vanish Coatings Accumulate As a Function of Age and Inactivity

After David M. Miller et al; USGS OFR 2014-1029

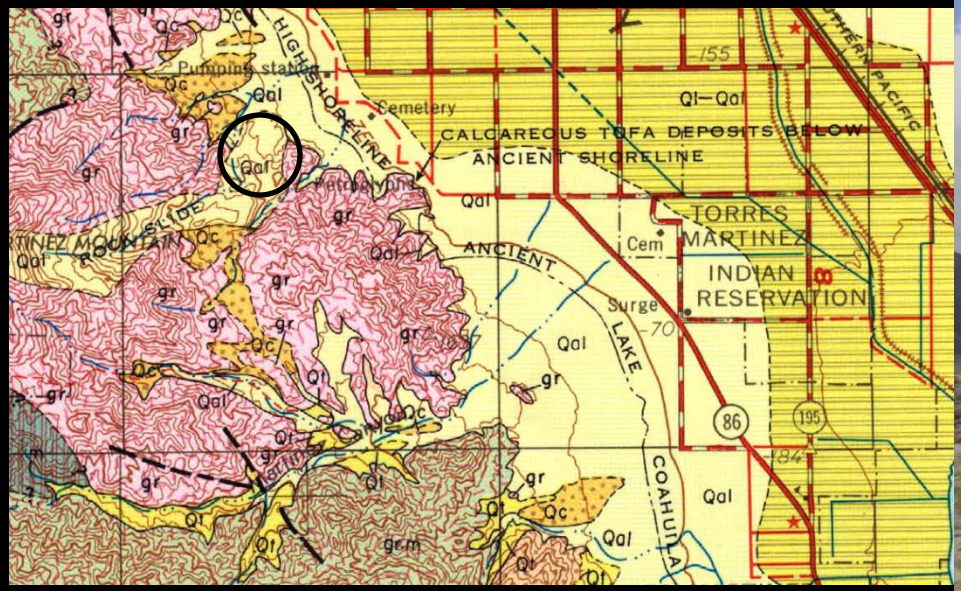
Colors on the fan are caused by desert varnish coatings on rocks. Inactive alluvial fan surfaces tend to form desert pavements which inhibits infiltration of water and enhances overland runoff and storm-triggered sheet flows.

USGS

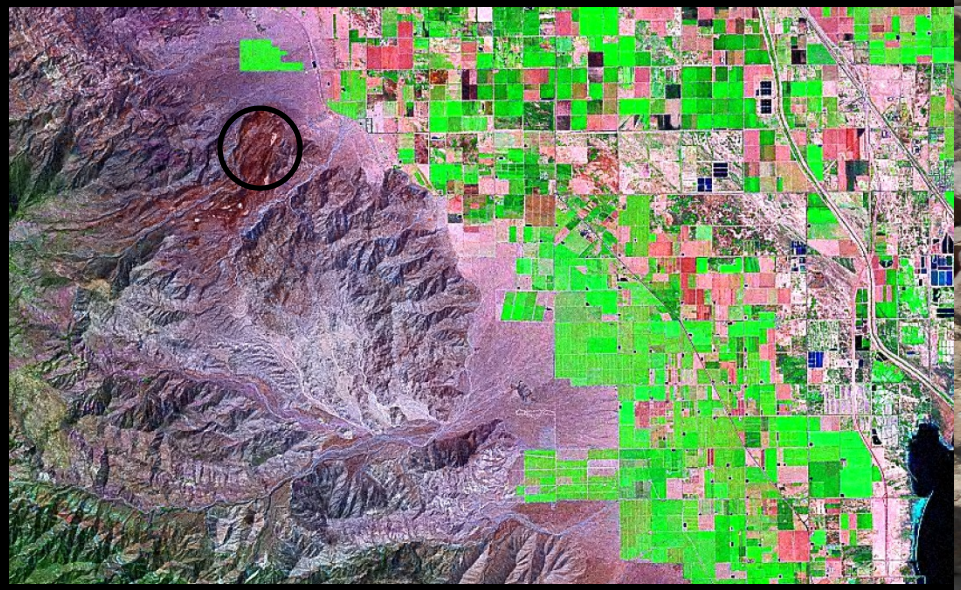


From Miller and others, 2009

Holocene? Aged Martinez (Rockslide Avalanche) Landslide – Part 1

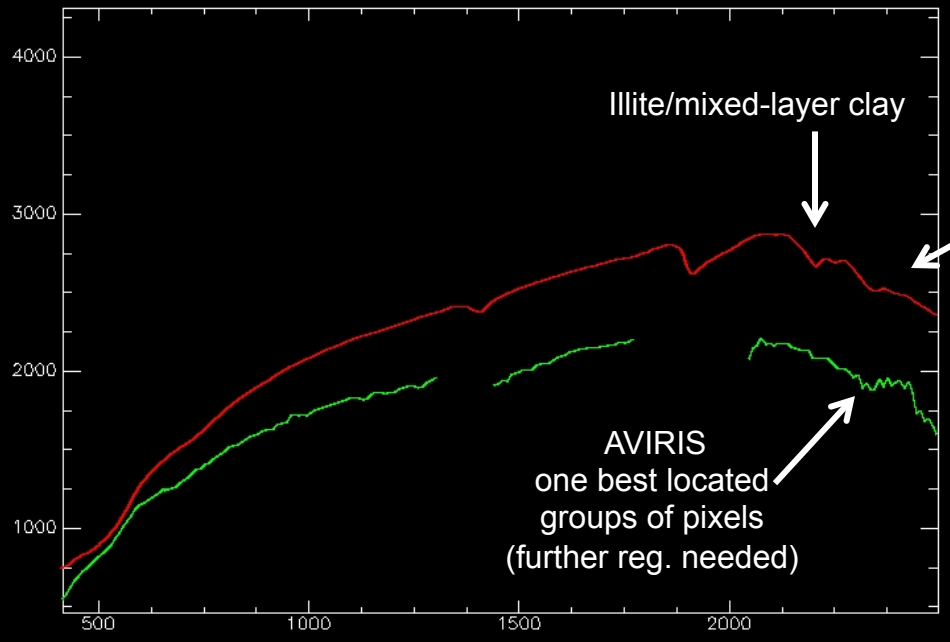


Note that it is the most desert varnish coated geologic feature in the basin & perhaps older than surrounding alluvial fans (i.e. a spectral endmember)



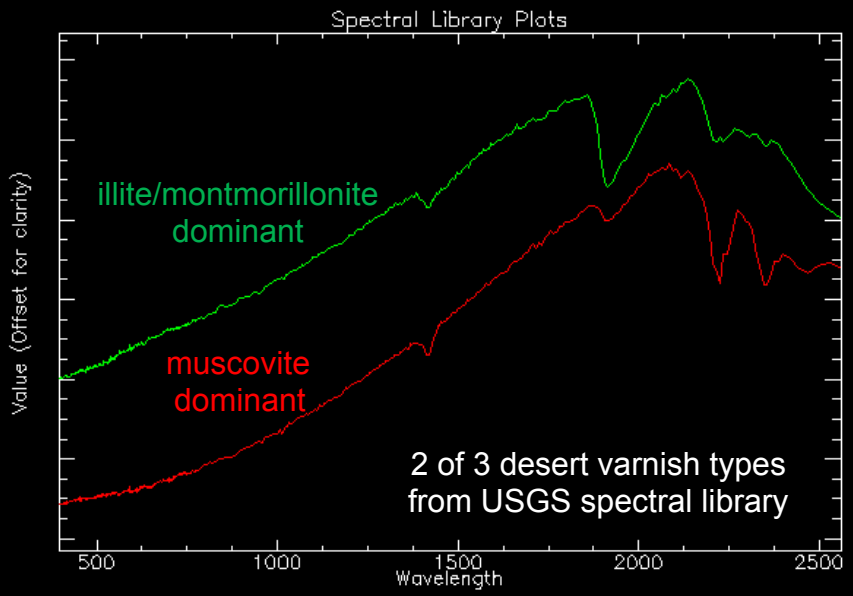
Toe is >100-m above ancestral lake level, but yet abundant & intact gastropod shells can be found high up on the upper toe

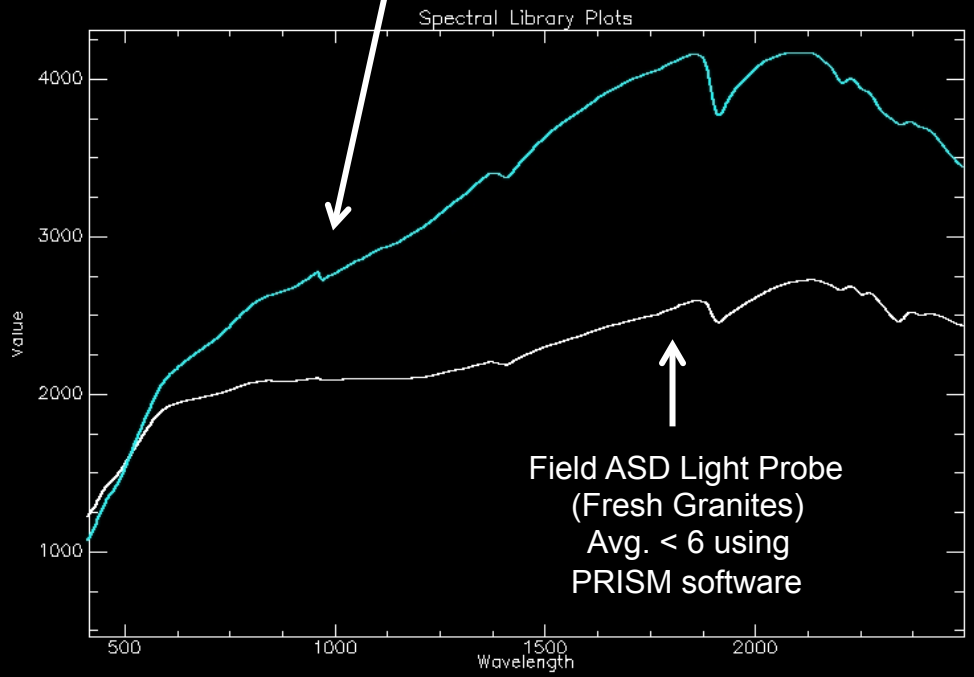
Holocene? Aged Martinez (Rockslide Avalanche) Landslide – Part 2



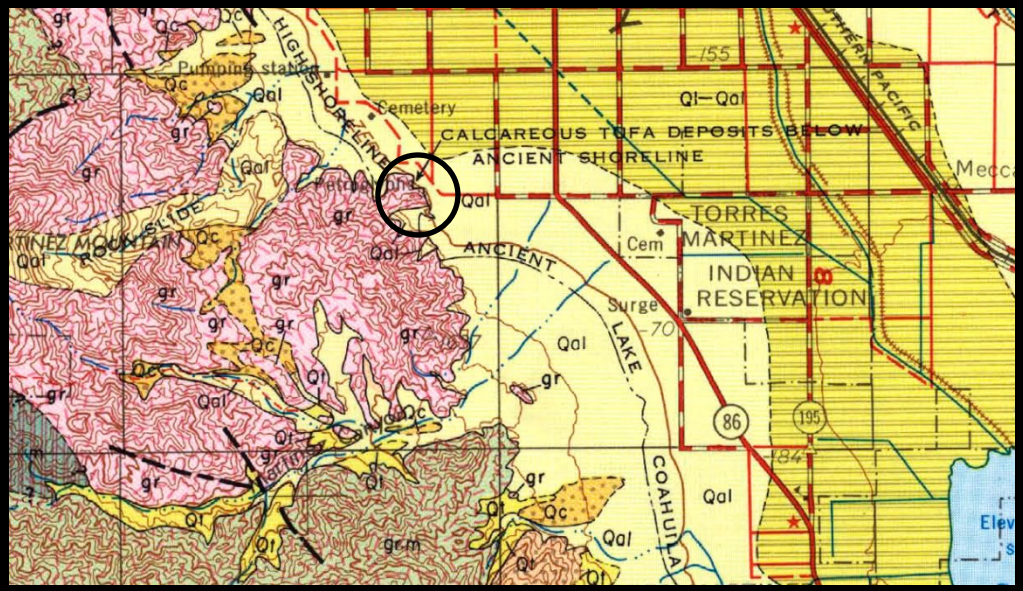
Field ASD Light Probe
(Desert Vanished Granites)
Avg. of ~40-50 using
PRISM software

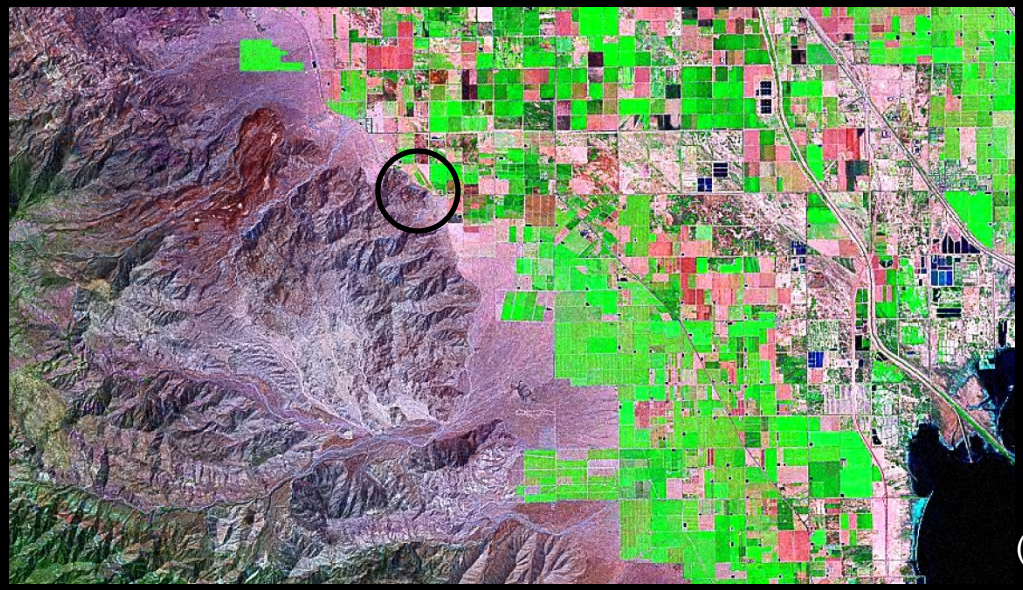
Field ASD Light Probe
(Bright Soil/Avalanche Matrix)
Avg. < 6 using
PRISM software
{Note dominance of Fe^{2+} + Fe^{3+} varnish}

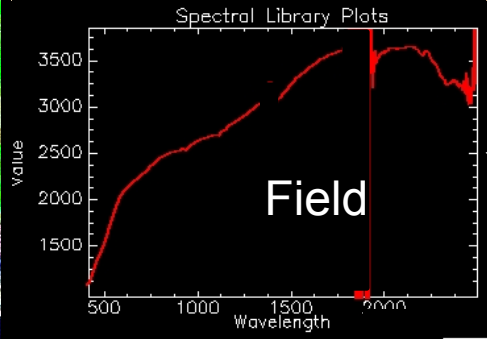




Complexities of Separating and Dating Lake, AF and Ancient Shoreline Deposits

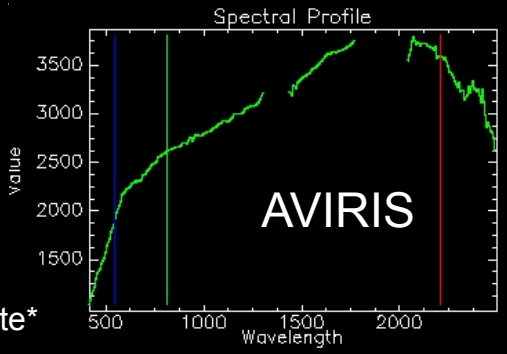






Avg. of ~40-50 using PRISM software

One best located pixel (further reg. needed)

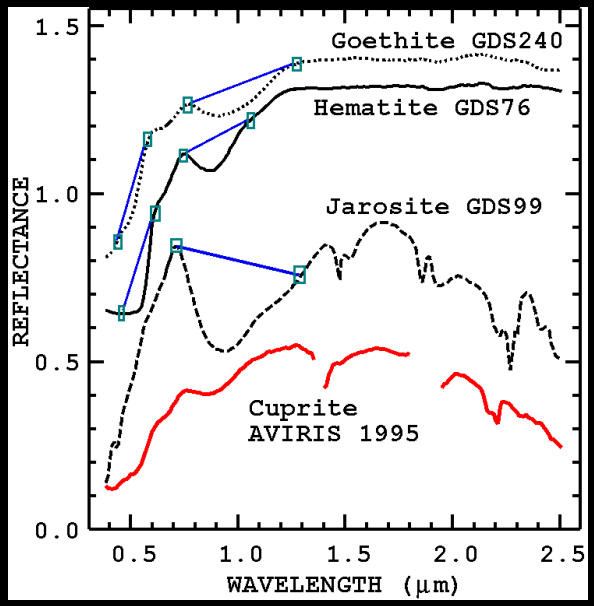


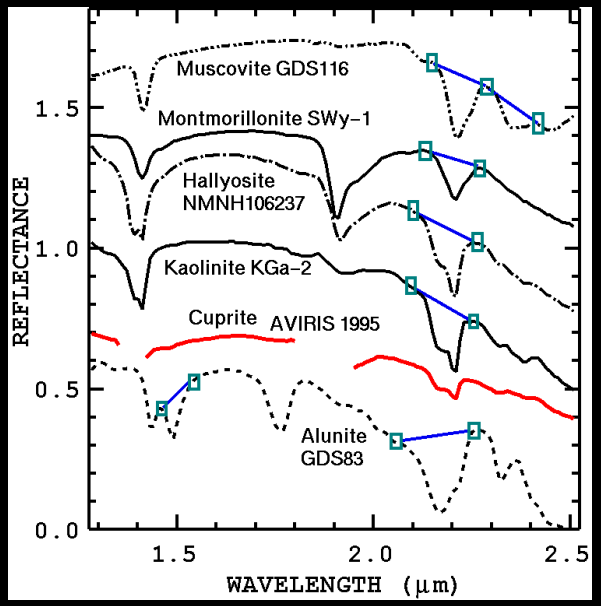
Greener Vegetation = Creosote Bush (*Larrea Tridentata*)
Senescent Vegetation = White Bursage (*Ambrosia Dumosa*)

Sparse desert varnish at this site

Image & Spectral Analyses Methods Being Employed in a Synergistic Manner

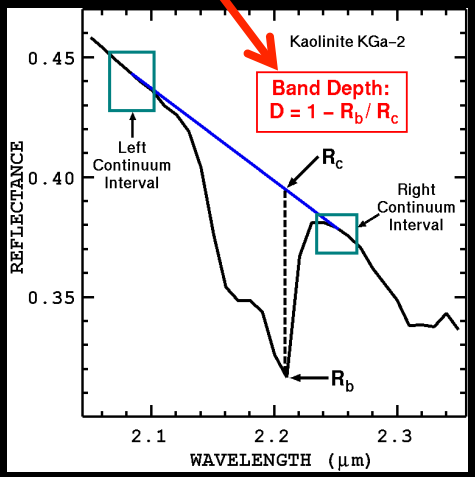
Tetracorder Approach (Clark et al., 2003) {Implemented as PRISM-MICA by Kokaly, 2011}





1) continuum-removal (i.e. bkgrnd-norm)
2) least squares linear regression
3) absorption feature band-depth analysis
4) fit * depth determination, weights & nots
5) compare observed to spectral library
6) 1- & 2- micron features done separately
7) pixel classification and/or material ID
8) a good command file is critical

Also useful as a means of determining relative abundances between sample targets, spectral libraries and/or remote sensing pixels



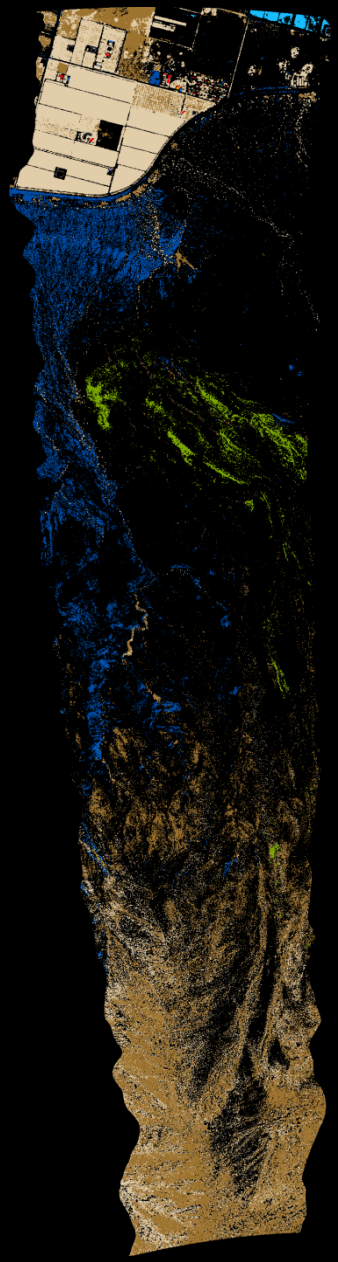
Linear Deconvolution Approaches*:

- Fully Constrained Linear Spectral Unmixing Methods
  - Linear Spectral Mixture Analysis (SMA/LSU)
  - Multiple Endmember Spectral Mixture Analysis (MESMA)
- Partial (Unconstrained) Spectral Unmixing Methods
  - Matched-Filtering (MF)
  - Mixture Tuned Matched-Filtering (MTMF)
  - Spectral Hourglass Methods {F. Kruse & J. Boardman}
    - PCA (MNF), Pixel Purity Index (PPI), MTMF

* Each of the two approaches have advantages & disadvantages, we prefer the former but will likely settle with the latter. For example, our study area consists of mixtures of urban areas, agricultural areas, and various geologic targets. We are more interested in those mineral mixtures (e.g. desert varnish & clay-rich soil crusts) characterizing specific geologic targets.

MICA/Tetracorder Analysis of AVIRIS-ng Imagery Covering the Martinez Landslide Deposit

AVIRIS-ng
resampled channels:
R = 0.6578 µm
G = 0.5406 µm
B = 0.4531 µm

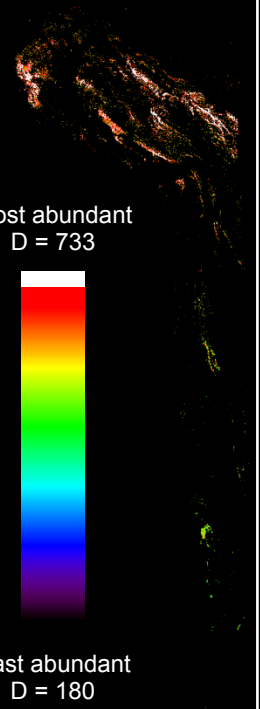


MICA 1-micron
mineral map*:

- desert varnish (DV)
- chlorite + muscovite (Fe^{2+} & Fe^{3+} features)
- greener vegetation types
- drier vegetation types
- Fe^{2+} - Fe^{3+} feature type resembling olivine (man-made/anthropogenic?)

* Corresponding MICA 2-micron map not shown in consideration of time, but shows carbonate minerals related to the ancient lake shoreline, as well as the smaller playas on top of the landslide deposit. AVIRIS classic & HyspIRI-convolved mapping results shown in later slides, as well as possible hydrothermal alteration minerals In the landslide source scarp area

MICA 1-micron
DV band-depth
values (proxy for
relative abundances)



most abundant
D = 733

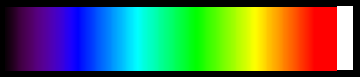
least abundant
D = 180

Pixels on higher end of scale tested using pixel purity methods and chosen as spectral endmembers for partial linear unmixing

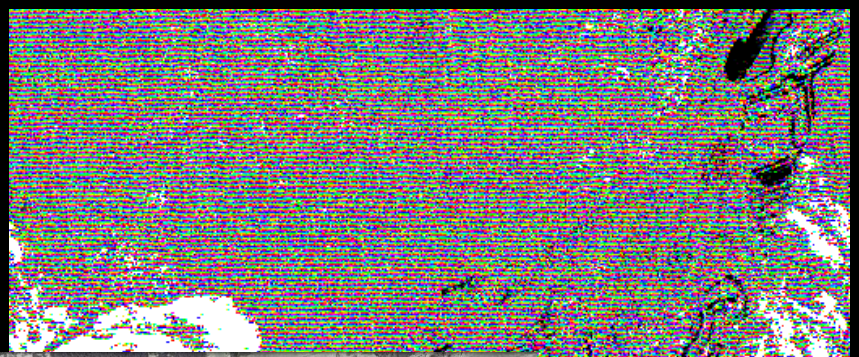
Partial Spectral Unmixing (matched-filter) Results Using AVIRIS-classic {Granite bedrock areas and alluvial fans closest to the Martinez Landslide}

AVIRIS-classic channels:
R = 0.6578 μm
G = 0.5406 μm
B = 0.4531 μm

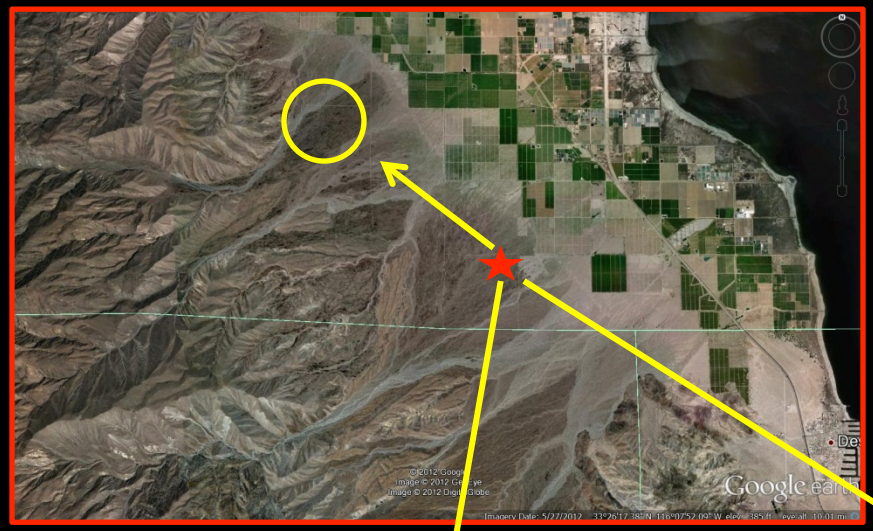
least abundant
0% DV

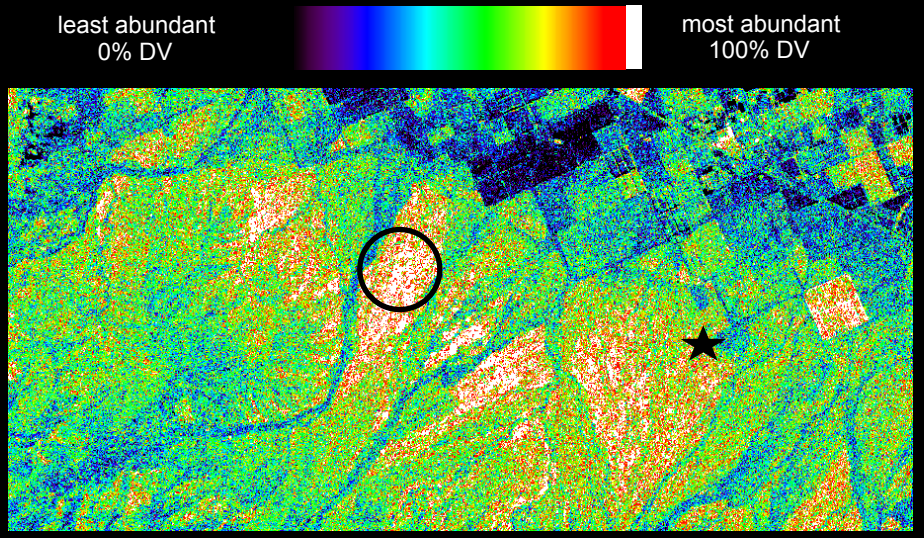


most abundant
100% DV



Perhaps The Oldest Alluvial Fan Terrace (But We Could Not Access It)

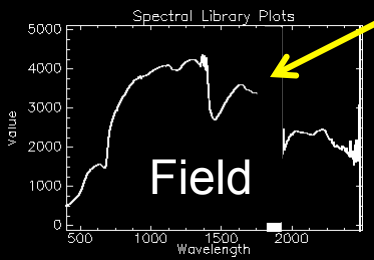




Example of a Well-Developed Desert Vanish & Desert Pavement Training Site

Inactive desert pavement (predominantly non-channelized, overland runoff)

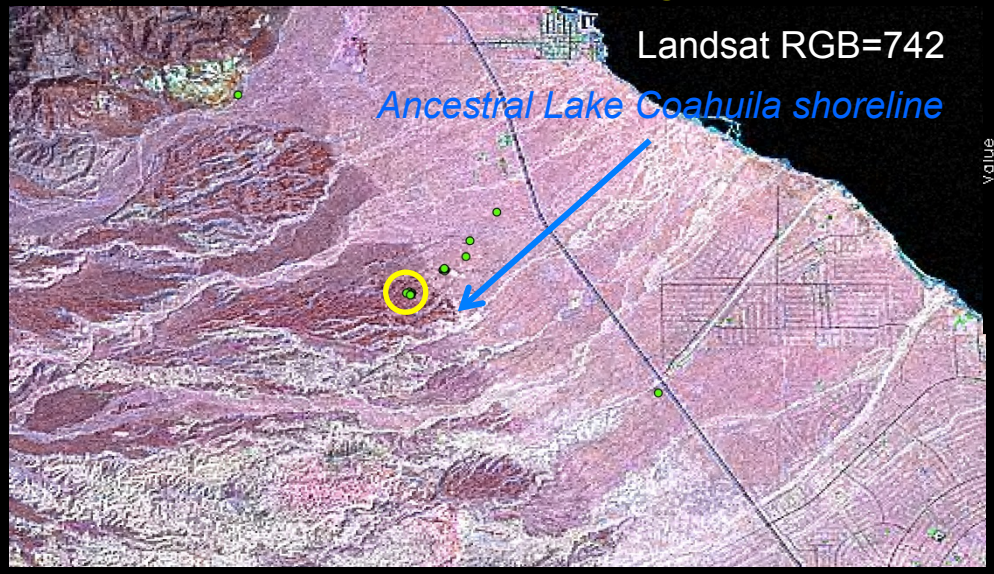
leveed & desert varnished (sieve) deposits

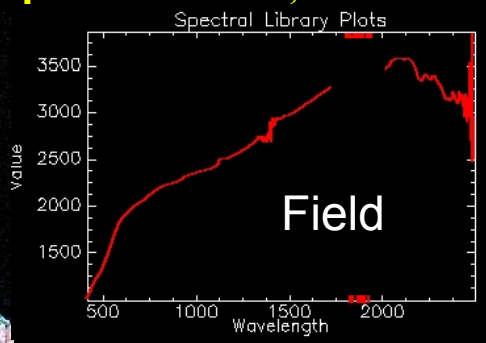


Creosote Bush (*Larrea Tridentata*)

sandier (relatively more active) channelized flow deposits

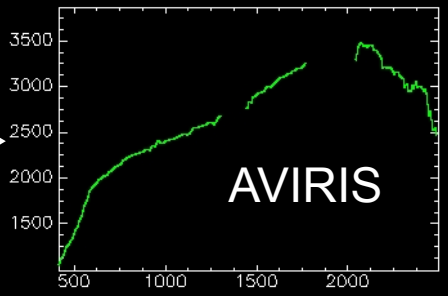
Another Well-Developed Desert Vanish & Desert Pavement Training Site
(Off the two AVIRIS-classic flight lines shown in previous slides, but covered on another line)



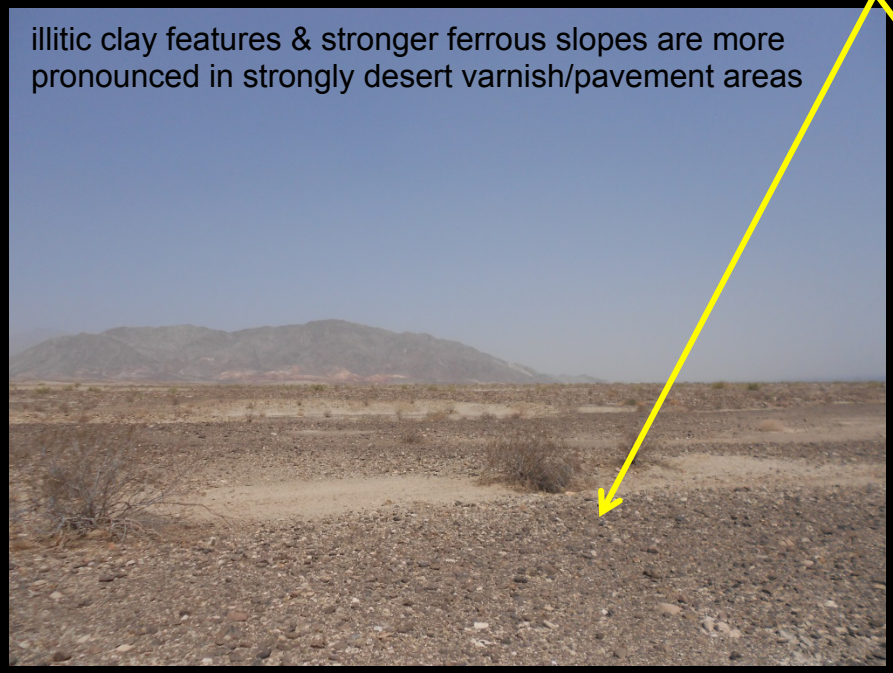


Avg. of ~40-50 using PRISM software

one best located groups of pixels (further reg. needed)



Even the sieve deposits have become desert pavement, channelized flow areas are now sparser in upper fan region



Summary of Results (Key Highlights & Take Home Points):

- Source scarp alteration areas were not (safely or logistically) accessible for field sampling & study

- Abundant buddingtonite was verified in Buzzard Peaks site with samples analyzed in laboratory
  - Field and Laboratory results are forthcoming (landslide hazards may be related to hydrothermal alteration)

- Spectral unmixing of desert varnished sieve deposits & desert pavement surfaces can contribute to relative dating
  - Results are preliminary and will be finalized using MTMF and/or MESMA

- Additional results not discussed here (e.g. role of montmorillonite change detection of soil crusts after major floods)