"Sandbar" geothermal field
Salton Sea, CA (16 Dec 12)

Initial science results of the NASA MAGI airborne instrument: Implications for environmental studies using HyspIRI data

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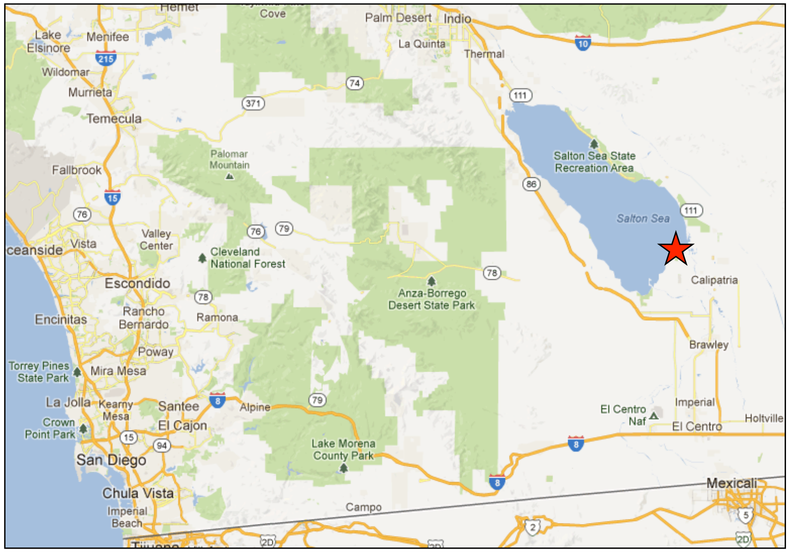
2013 HyspIRI Science Symposium
GSFC, MD (29 – 30 May 2013)

Overview

- **Salton Sea Geothermal Field (SSGF)**
  - geology and geothermal presence
  - prior TIR remote sensing results



- **MAGI Instrument**
  - brief background/specification
- **Data/Results**
  - data processing flow
  - Anomalies observed in the data
  - mineral identification at recently-exposed geothermal sites
- **Summary**
  - implications for environmental conditions and geothermal prospecting in the future with HyspIRI

Salton Sea Geothermal Field

- **Rationale**
  - prime geologic, thermal and logistical target
    - mineralogical diversity
    - exposed geothermal targets
    - accessibility
  - environmental target
    - lowering of the water level >1m in the last decade
      - exposed high saline deposits
      - fish die offs
      - potential airborne particulates
        - » *impose respiratory health issues*

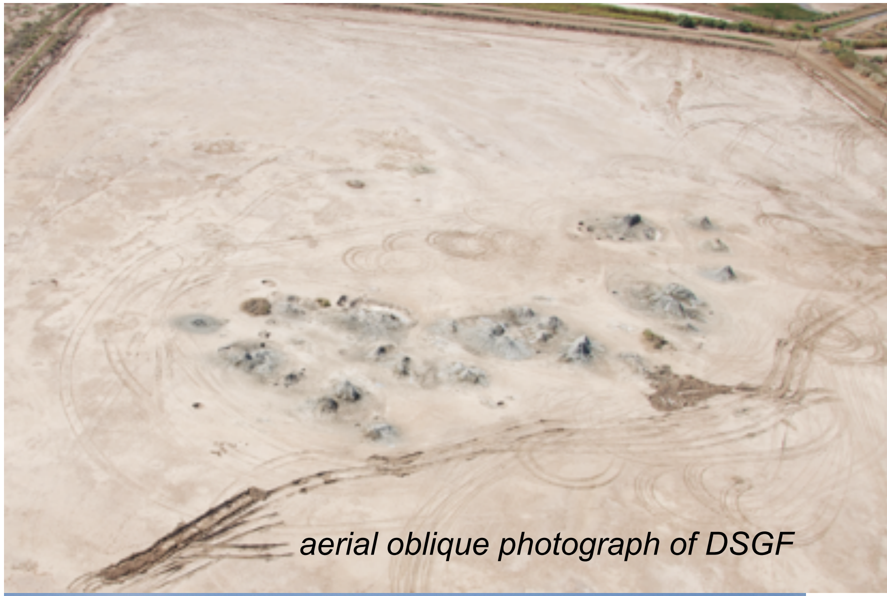
dead fish are common along the shoreline

Previous Work

- **Davis-Schrimpf Geothermal Field (DSGF)**
  - inland, lower temperatures and surface activity
    - mainly small mud volcanoes (gryphons) and warm springs
    - target of mineral mapping using SEBASS data
      - able to document subtle changes in sulfate mineralogy
      - precursory study for MAGI data

[Reath, 2011]

[Reath & Ramsey, 2013]



aerial oblique photograph of DSGF

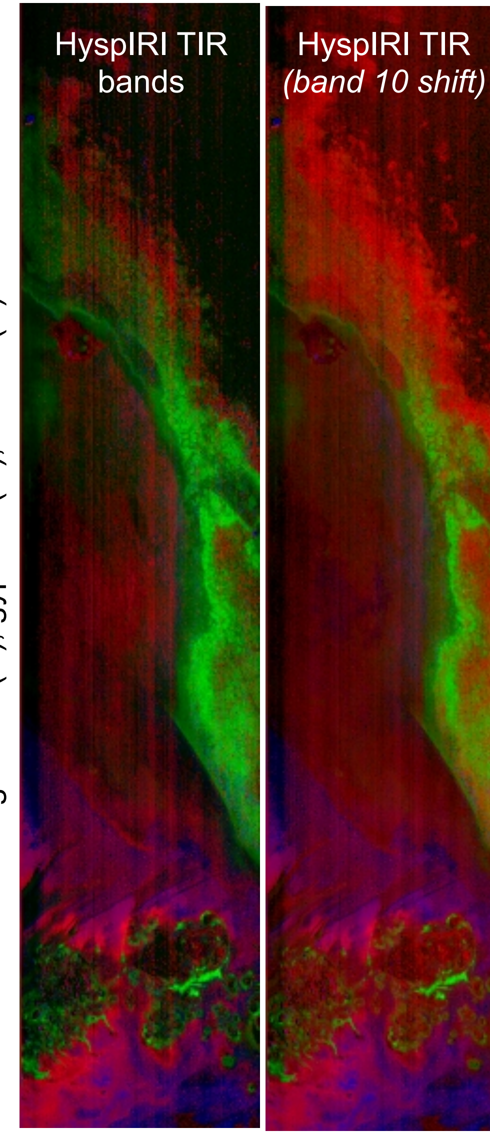
gryphon and warm spring (K. Reath)

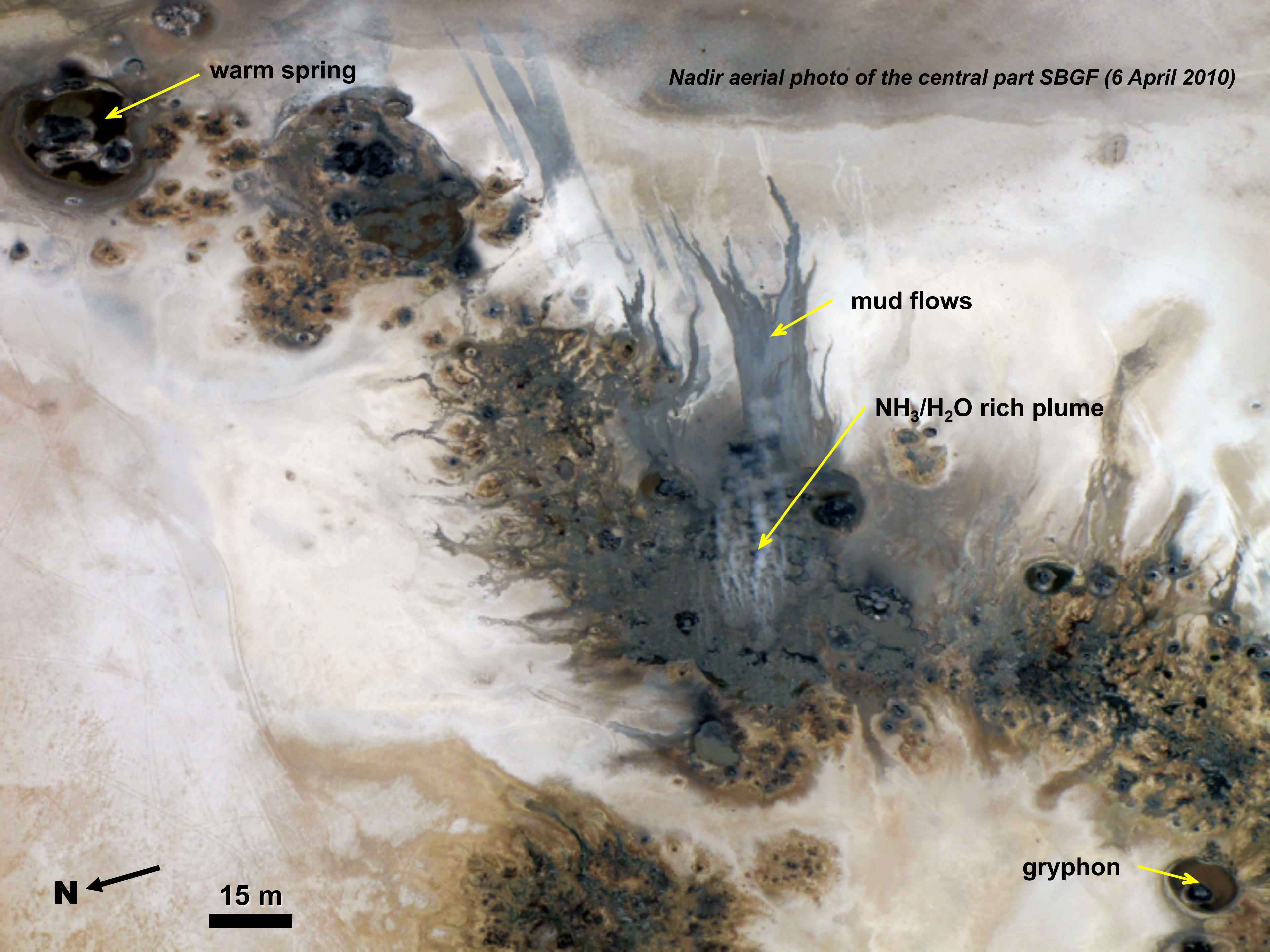
Previous Work

- **Sandbar Geothermal Field (SBGF)**
  - subaqueous in the past
  - recently exposed with lowering sea levels
  - higher temperatures and surface activity
    - vigorous gryphons, mud flows and warm springs
    - target of SEBASS mineral mapping
      - study effects of moving HyspIRI TIR band positions *[Ramsey, 2012]*

active gryphon (SBGF)

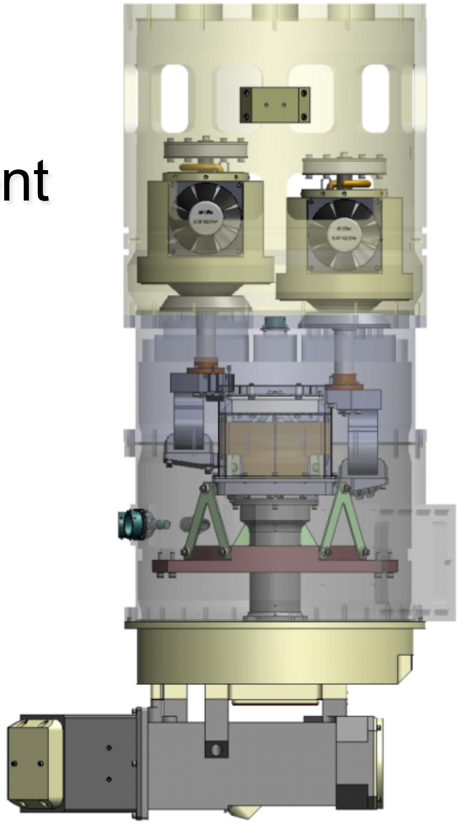
oligoclase (R), gypsum (G), calcite (B)




warm spring
Nadir aerial photo of the central part SBGF (6 April 2010)
mud flows
NH_3/H_2O rich plume
gryphon
N
15 m

Instrument Details

- **MAGI (Mineral And Gas Identifier) ***
  - airborne demonstrator sensor designed to support post-HyspIRI technology development
    - PI: Jeff Hall (Aerospace)
  - one of two airborne Instrument Incubator Program (IIP) IR instruments funded in 2009
  - thermal IR region (7.1 – 12.7 micron)
    - 32 spectral channels
  - 2m ground sampling from 12,000 ft AGL
  - five validation targets occurred in Dec. 2011
    - *included Coso (CA), Cuprite (NV), Salton Sea (CA), San Joaquin Valley (CA)*



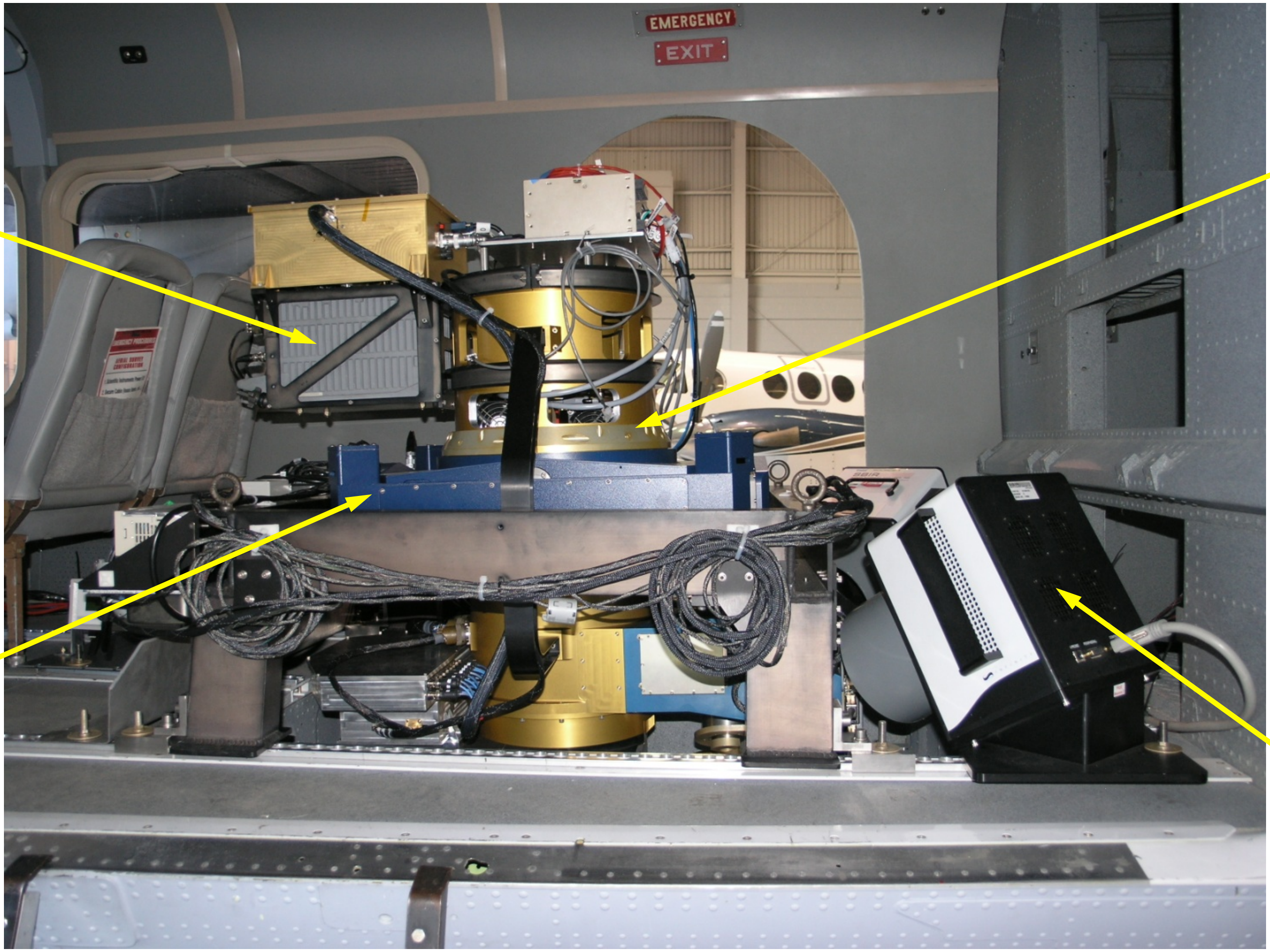
CAD model of the MAGI sensor core showing the components

** see poster by Hall et al. for more details*

MAGI On The Twin Otter

Inertial Navigation System

Sensor

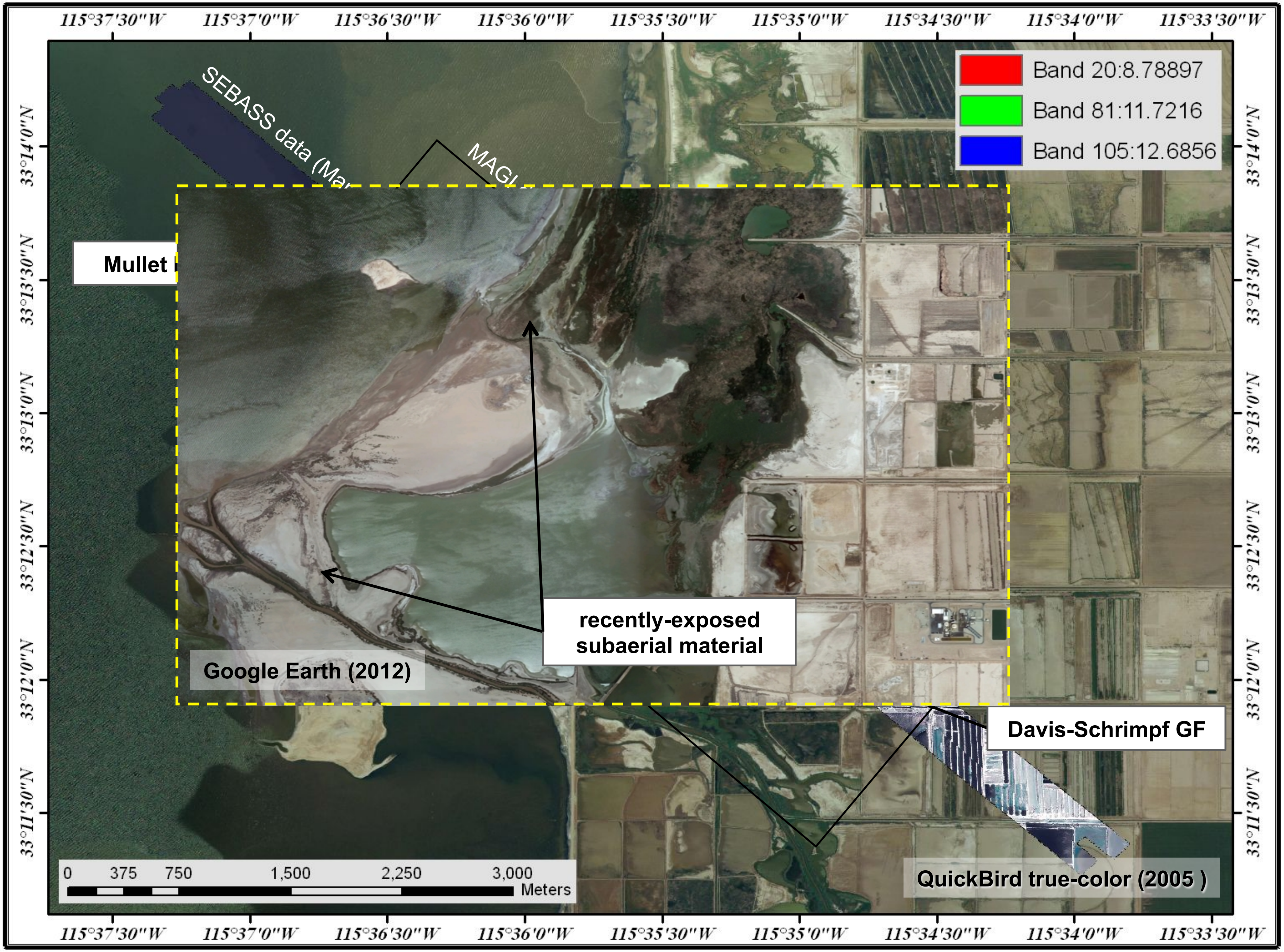


Three-Axis Stabilization Platform

Calibration Blackbody

MAGI Flights

- **Salton Sea Geothermal Field**
  - 9 December 2011 at 13:44 local time
  - 10,000 ft (3 km) AGL → GSD ~ 1.6 m
  - post-processing
    - each whisk calibrated to radiance-at-sensor *(μW/cm²/sr/μm)*
    - whisks mosaiced together
      - no corrections for whisk to whisk misregistration
    - atmospherically corrected using the In-Scene Atmospheric Compensation (ISAC) procedure *[Young et al., 2002]*
    - TE separation → emissivity normalization
    - spectral deconvolution → laboratory end-members
    - detectable scan line and bad pixel noise present
      - no corrections have been attempted for these as of yet

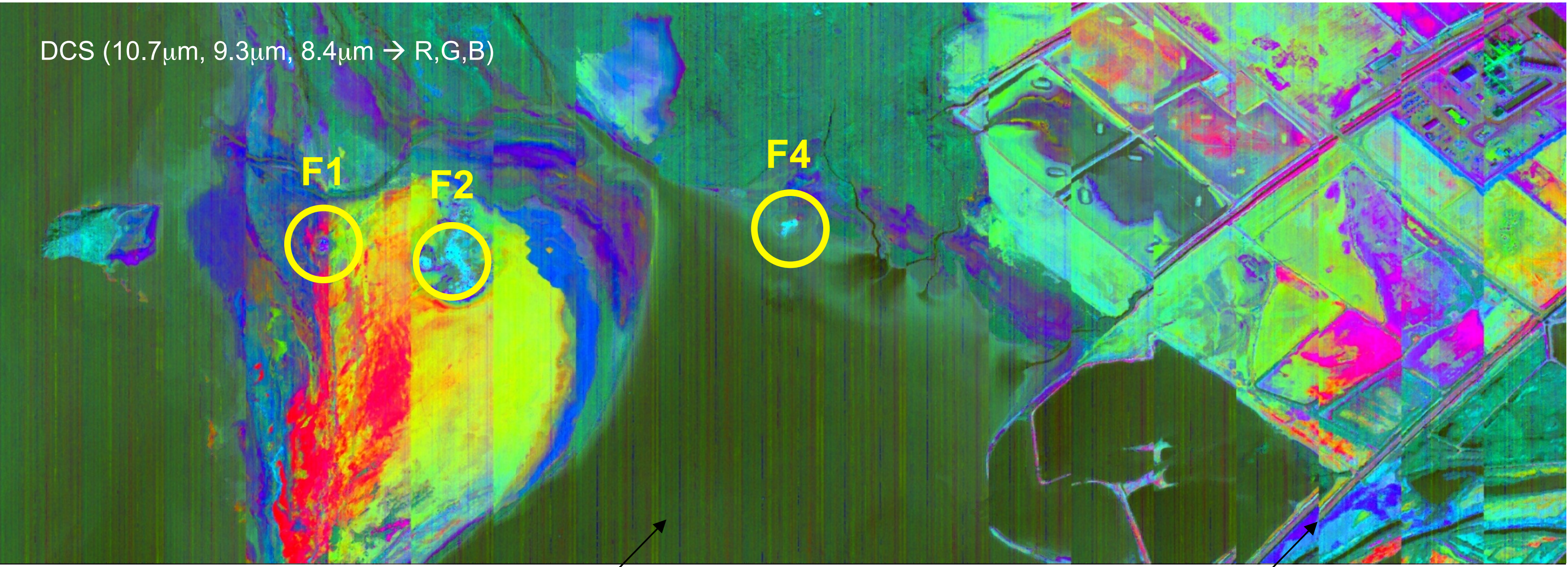


115°37'30"W
115°37'0"W
115°36'30"W
115°36'0"W
115°35'30"W
115°35'0"W
115°34'30"W
115°34'0"W
115°33'30"W
33°14'0"N
33°13'30"N
33°13'0"N
33°12'30"N
33°12'0"N
33°11'30"N
Band 20:8.78897
Band 81:11.7216
Band 105:12.6856
SEBASS data (Ma
MAGI
Mullet
recently-exposed subaerial material
Google Earth (2012)
Davis-Schrimpf GF
QuickBird true-color (2005)
0 375 750 1,500 2,250 3,000 Meters


MAGI data (Dec, 2011)
F1
F2
F4
sub-aerially exposed
thermally-elevated zones
(nomenclature of Lynch
et al., 2013)

Mosaic Data

- T_{max} = 89.1°C (F2), 74.9°C (F4), 60.3°C (F1)
- decorrelation stretch (DCS) in general highlights
  - quartz-rich minerals (red), evaporite-rich minerals (green), clay-rich minerals (blue)

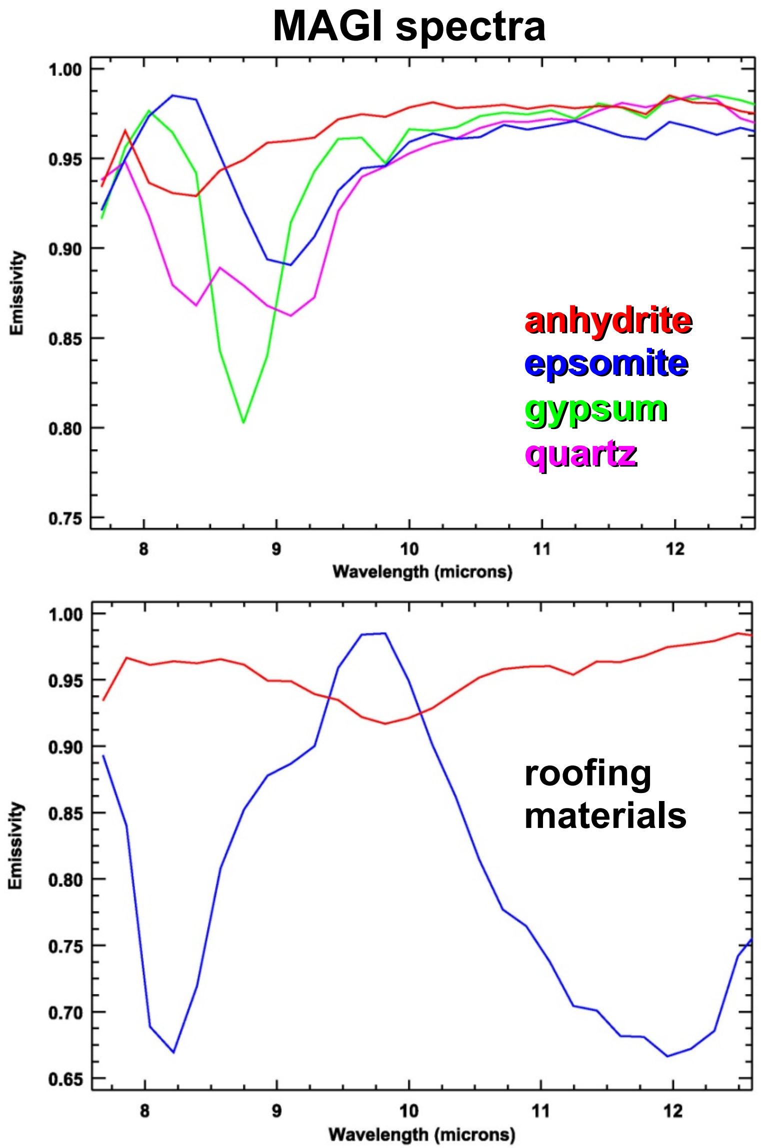


scan line noise accentuated by the DCS

whisk mosaic misregistration

Methods

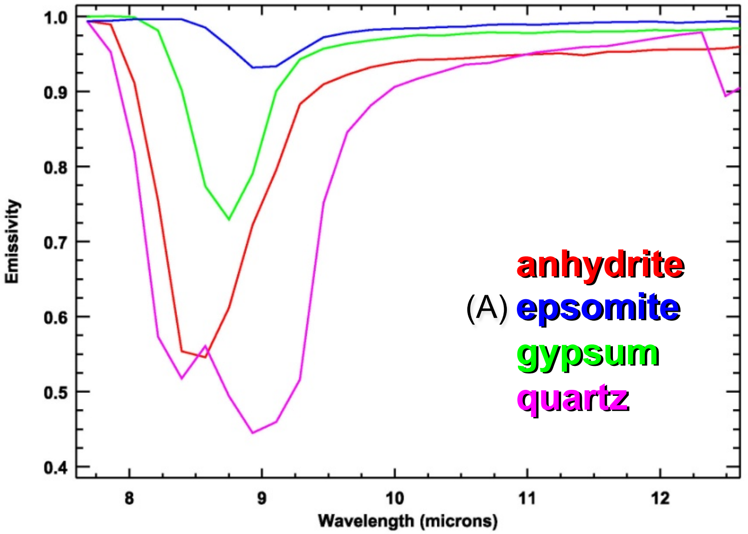
- **MAGI Emissivity Data**
  - spectral end-members identified visually and using ENVI's pixel purity index (PPI)
  - noted ~11 end-members that corresponded to known minerals:
    - <u>evaporites:</u> *anhydrite, calcite, gypsum, epsomite*
    - <u>phyllosilicates:</u> *talc, hectorite, Na-montmorillonite, nontronite*
    - <u>silicates:</u> *microcline, oligoclase, quartz*
  - several other unique signatures
    - roofing and industrial materials at geothermal power plant



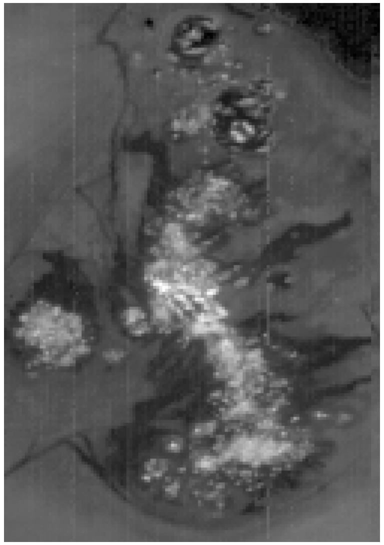
Methods

- **Mineral Identification**
  - spectral deconvolution approach *[Ramsey and Christensen, 1998]*
  - examined both image and library-based spectral end-members
    - work presented here is using library-based end-members

ASU library spectra

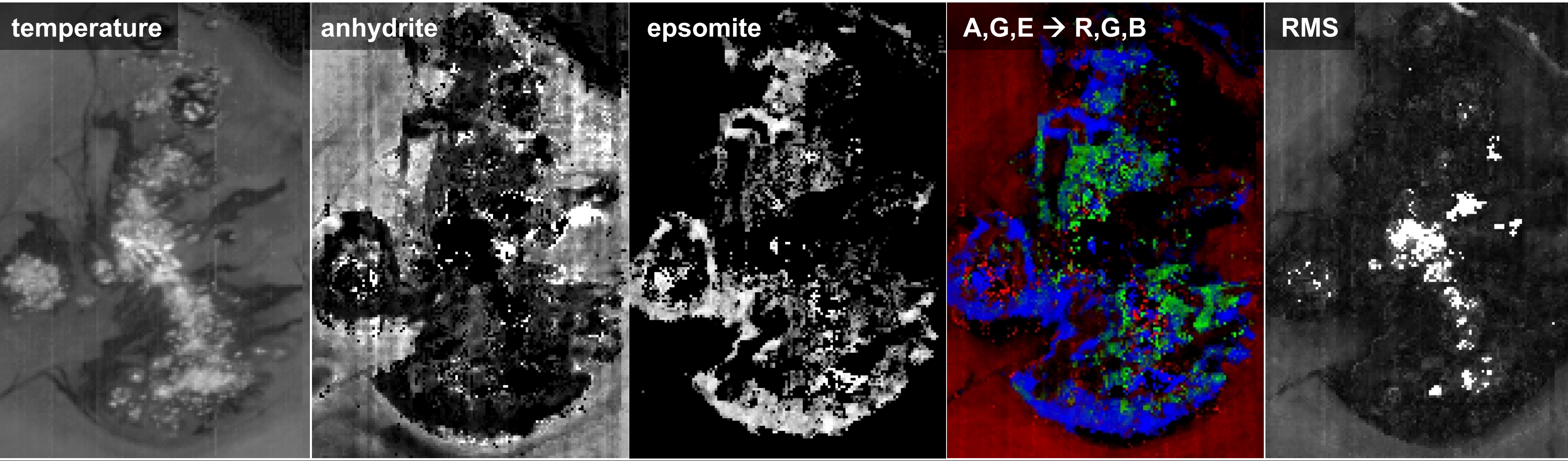


- **Temperature**
  - temperatures of the fumarole fields compared to mineral identification

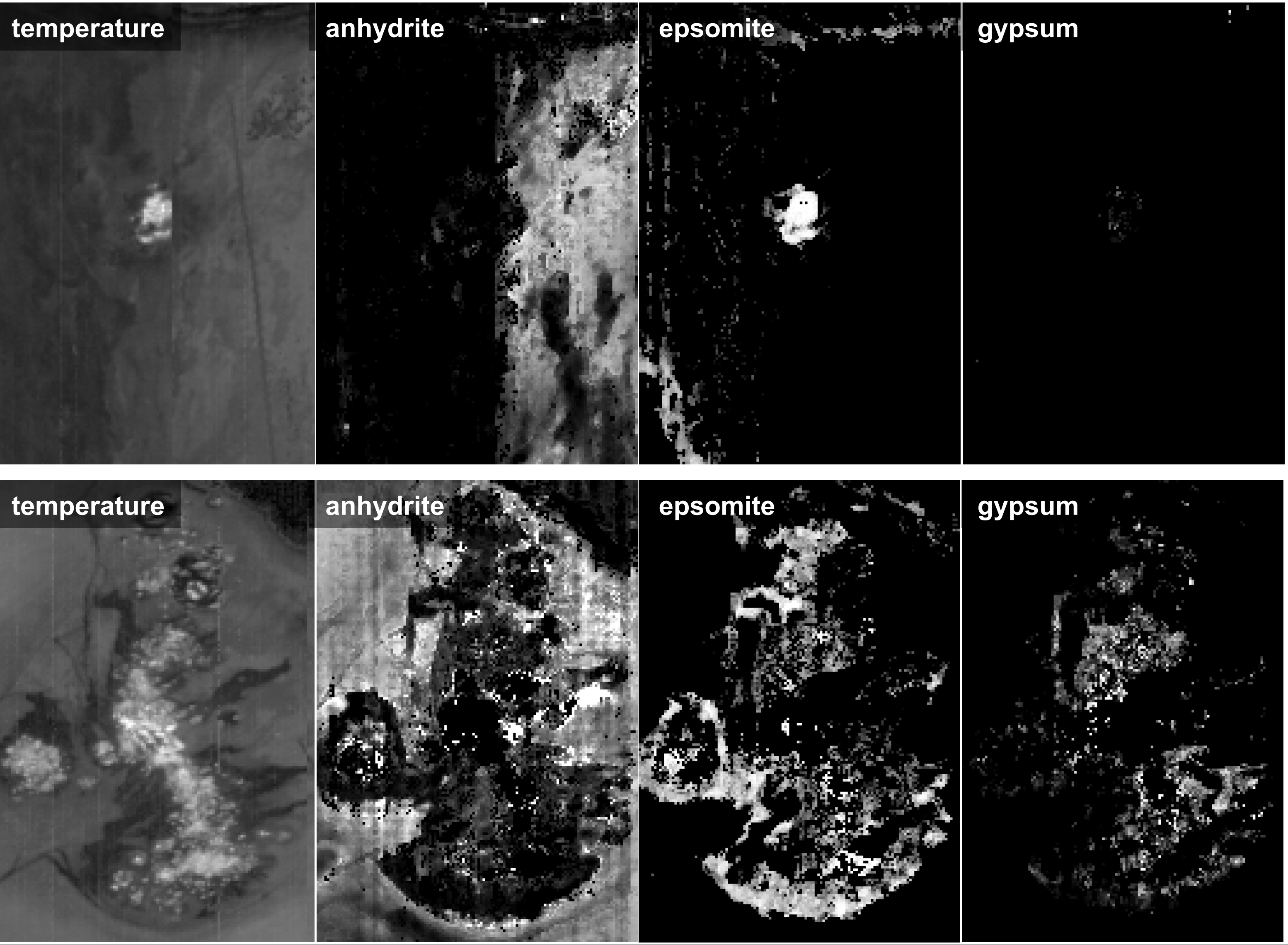


Initial Results

- **F2 Site**
  - "cores" of the active thermal features suffered from sub-pixel thermal mixing making identification difficult
  - progression of gypsum, epsomite, anhydrite from center to edges of the thermal features
    - indicate formation temperature ± dehydration reactions
      - e.g., gypsum dehydrates > 50°C



Initial Results



- **F1 site:**
  - T_{max} = 60.3 °C
  - ↓ gypsum
  - max = 31.9%
  - ↑ epsomite
  - max = 98.4%
- **F2 site:**
  - T_{max} = 89.1 °C
  - ↑ gypsum
  - max = 78.5%
  - ↓ epsomite
  - max = 49.1%

surface mineralogy moving away from F2 site *(left → right)*

(general progression from gypsum to epsomite to anhydrite to quartz/clay)

Conclusions

- **MAGI Data**
  - proving to be a well-calibrated dataset
  - spectral resolution sufficient for surface mineralogy
  - also identified NH_3 plumes *[see Hall et al. poster]*
  - noise clean up and whisk registration tools still required
  - other data sets currently under analysis

- **Salton Sea Geothermal Field (SSGF)**
  - diversity of thermal/compositional targets
  - general correlation of fumarole temperature and mineral formation temperature
  - lower sea level has exposed large land areas
    - mix of finer-grained quartz, clay, and evaporite minerals
      - could be easily mobilized by the wind