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Hyperspectral Imaging: Spor Mountain Critical Minerals Evaluation

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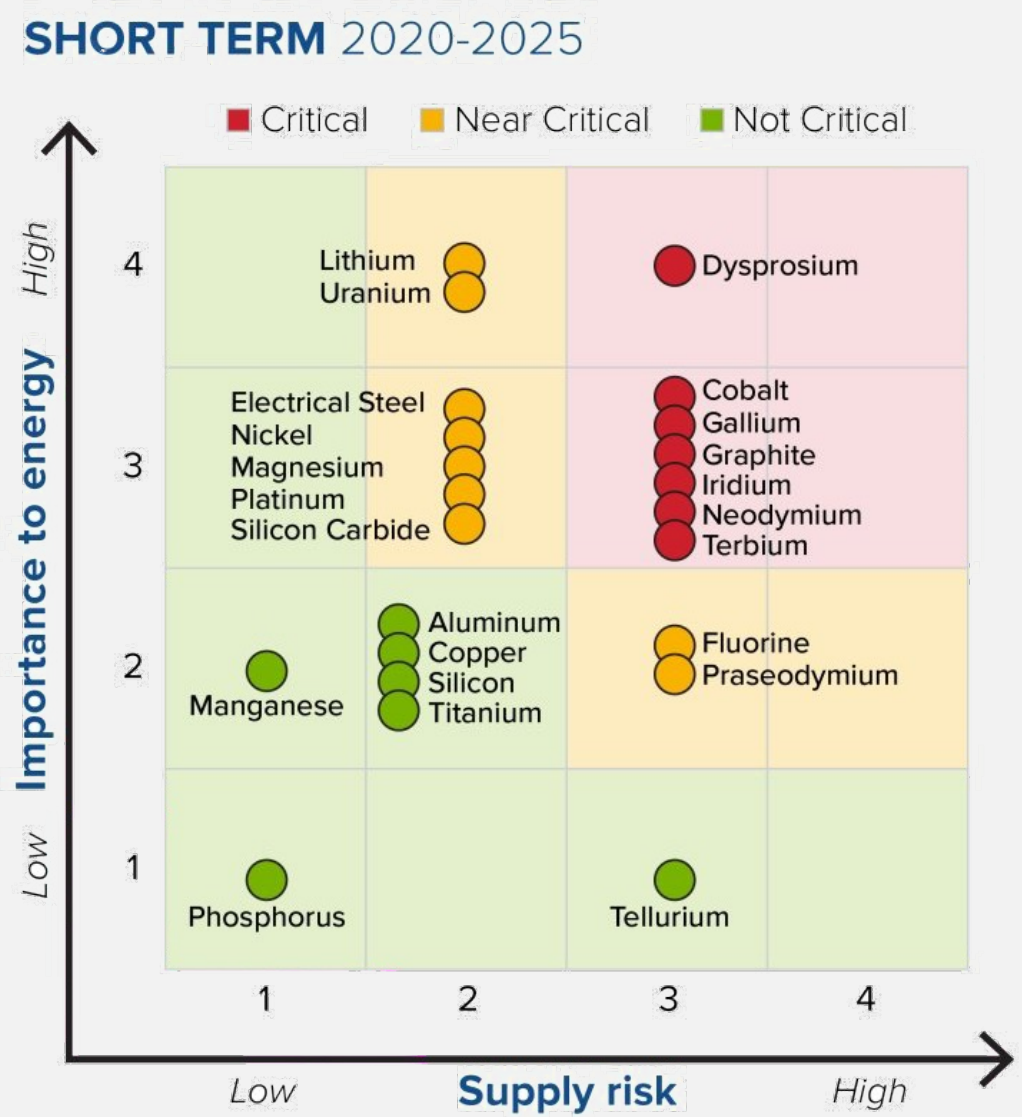
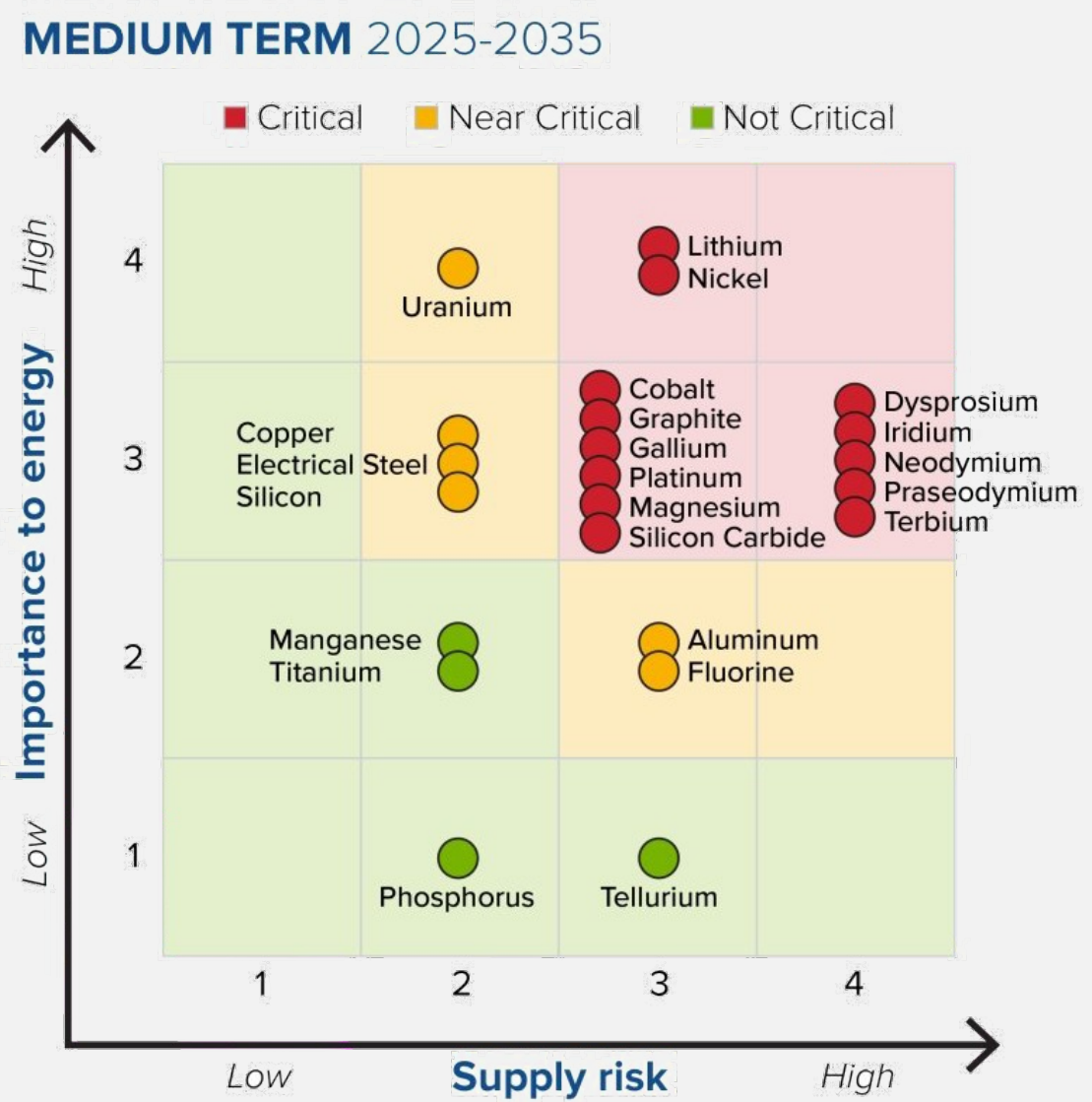
AMERICA'S RELIANCE ON CRITICAL MINERALS





AMERICA'S RELIANCE ON CRITICAL MINERALS

RARE EARTH ELEMENTS

REEs, such as neodymium, dysprosium, and europium, are often associated with certain types of mineral deposits. Tailings from mining operations targeting minerals like monazite, bastnäsite, and xenotime can contain significant amounts of REEs.

LITHIUM

Tailings from lithium-bearing minerals, such as spodumene, lepidolite, and petalite, can be potential sources of lithium. These minerals are commonly associated with pegmatite deposits.

COBALT

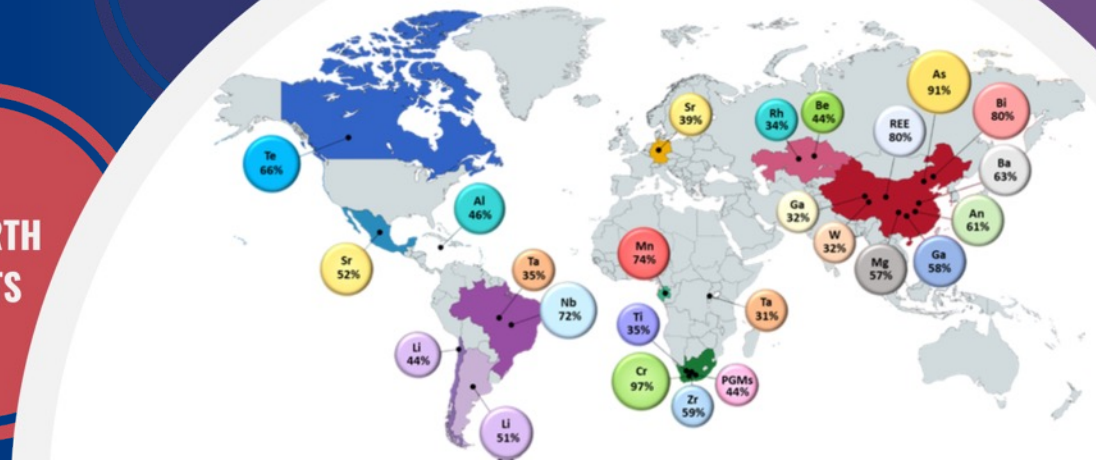
Cobalt is often found as a byproduct of copper and nickel mining. Tailings from copper and nickel operations, particularly those targeting sulfide ores, may contain cobalt as well.

TUNGSTEN

· Tailings from tungsten mines can contain residual tungsten minerals like scheelite and wolframite. These minerals are commonly associated with hydrothermal vein-type deposits.

VANADIUM

Vanadium is typically extracted as a byproduct of other mining operations, such as those targeting iron ore or uranium. Tailings from these operations may contain vanadium minerals like magnetite or carnotite.



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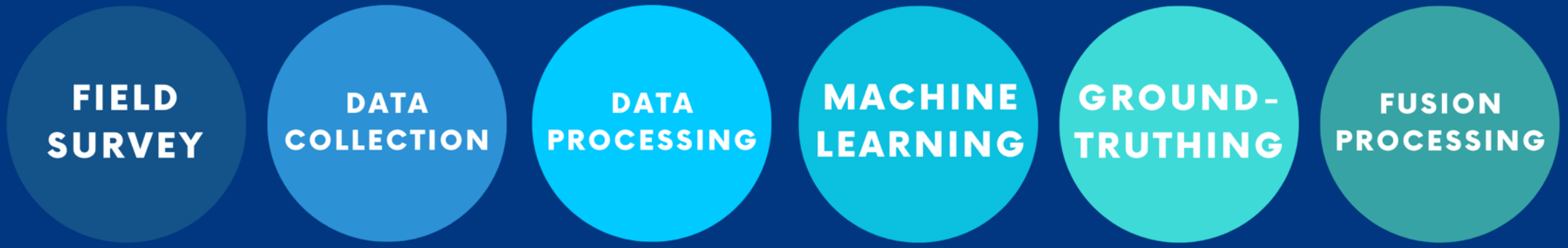
IMAGING 101

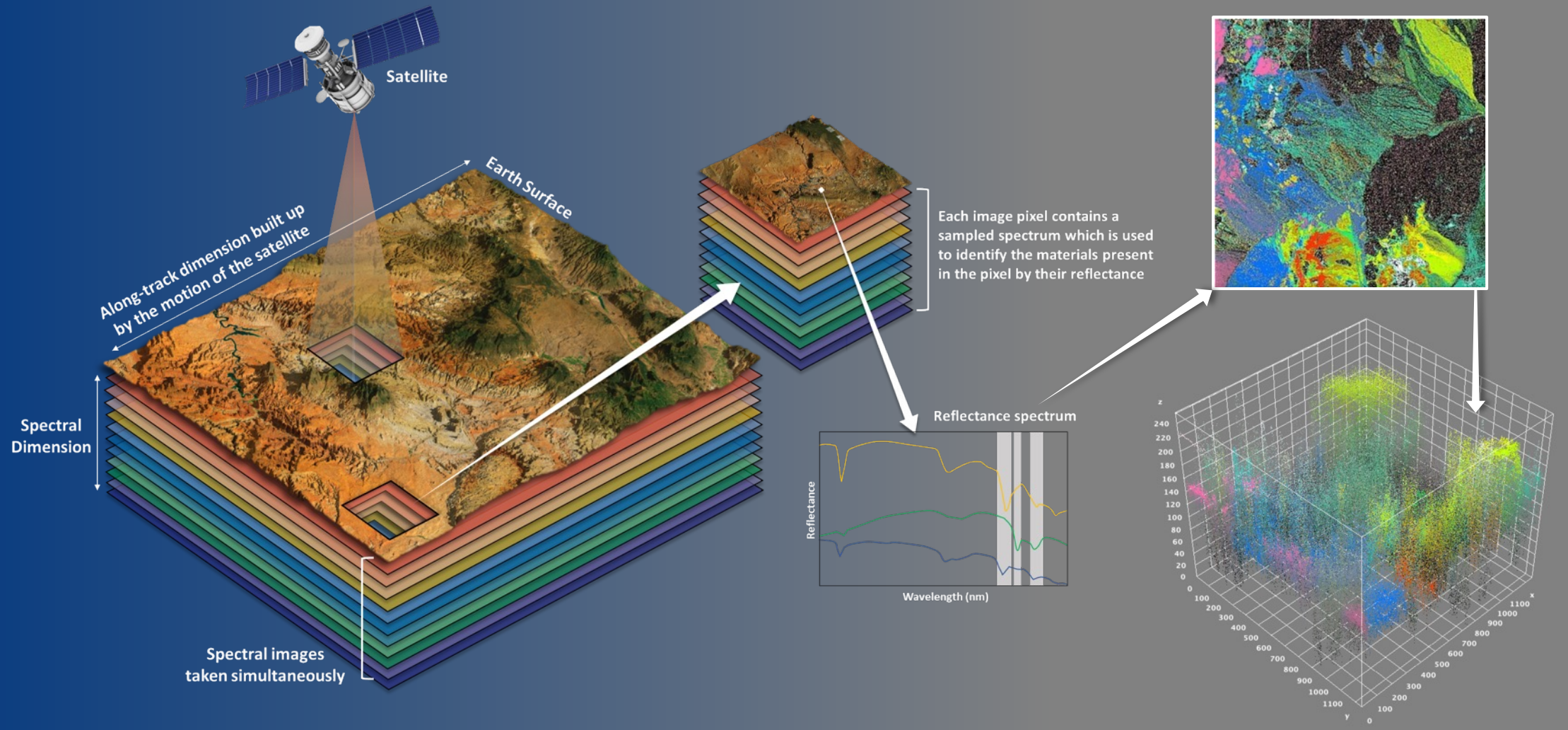
HYPOTHESIS: Application of hyperspectral imaging technology at Spor Mountain, Utah, will enable the precise identification and characterization of critical minerals within the region, offering valuable insights into their distribution, abundance, and potential economic viability. HI has the potential to facilitate the sustainable and efficient extraction of essential minerals from geologically significant areas.

WHY SOLVE?: Determine hyperspectral imaging algorithms and bands ratios (math) that find critical minerals/materials using the Spor Mountain analogue. Use results for other geologically similar areas.

METHODOLOGY:

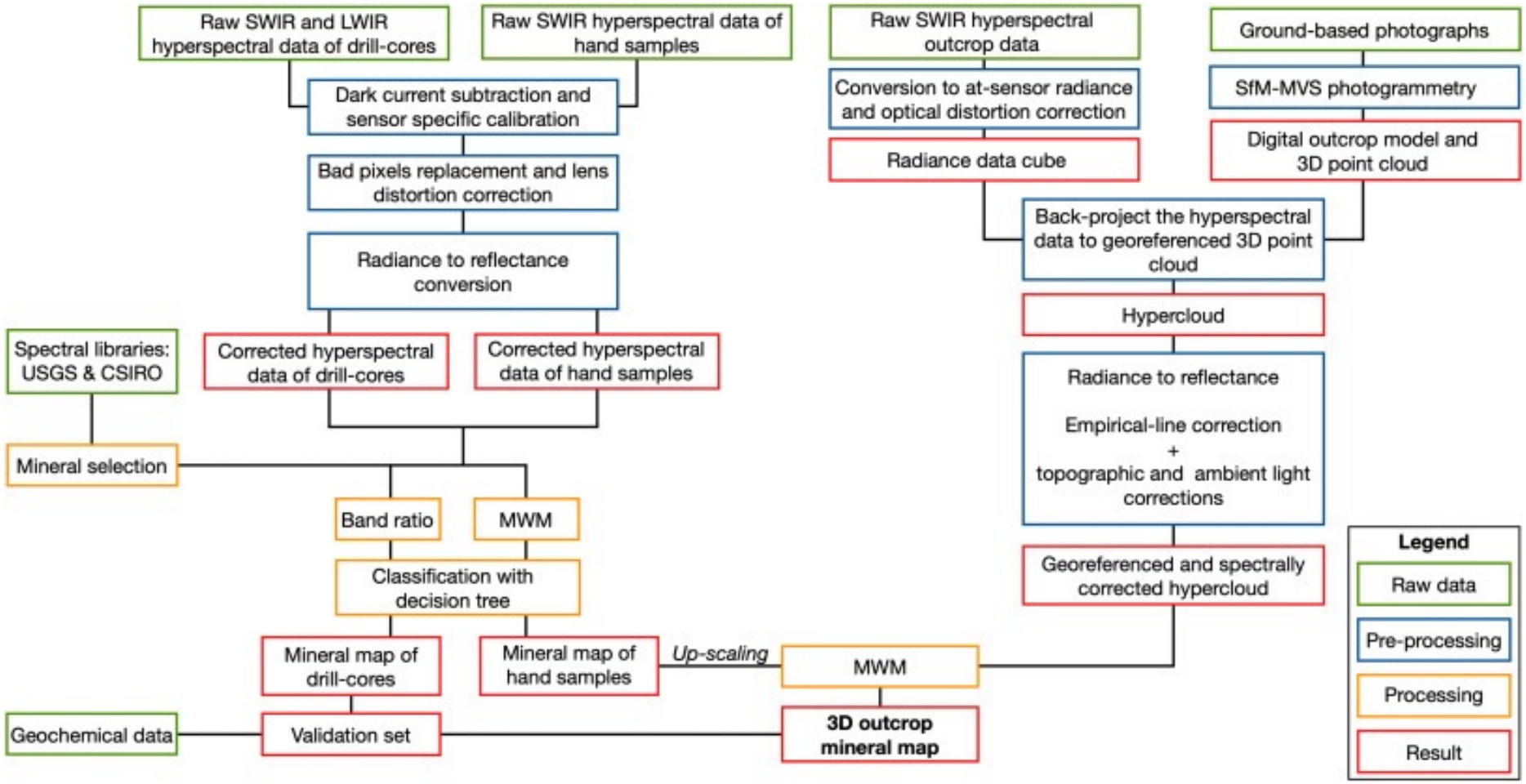


IMAGING 101

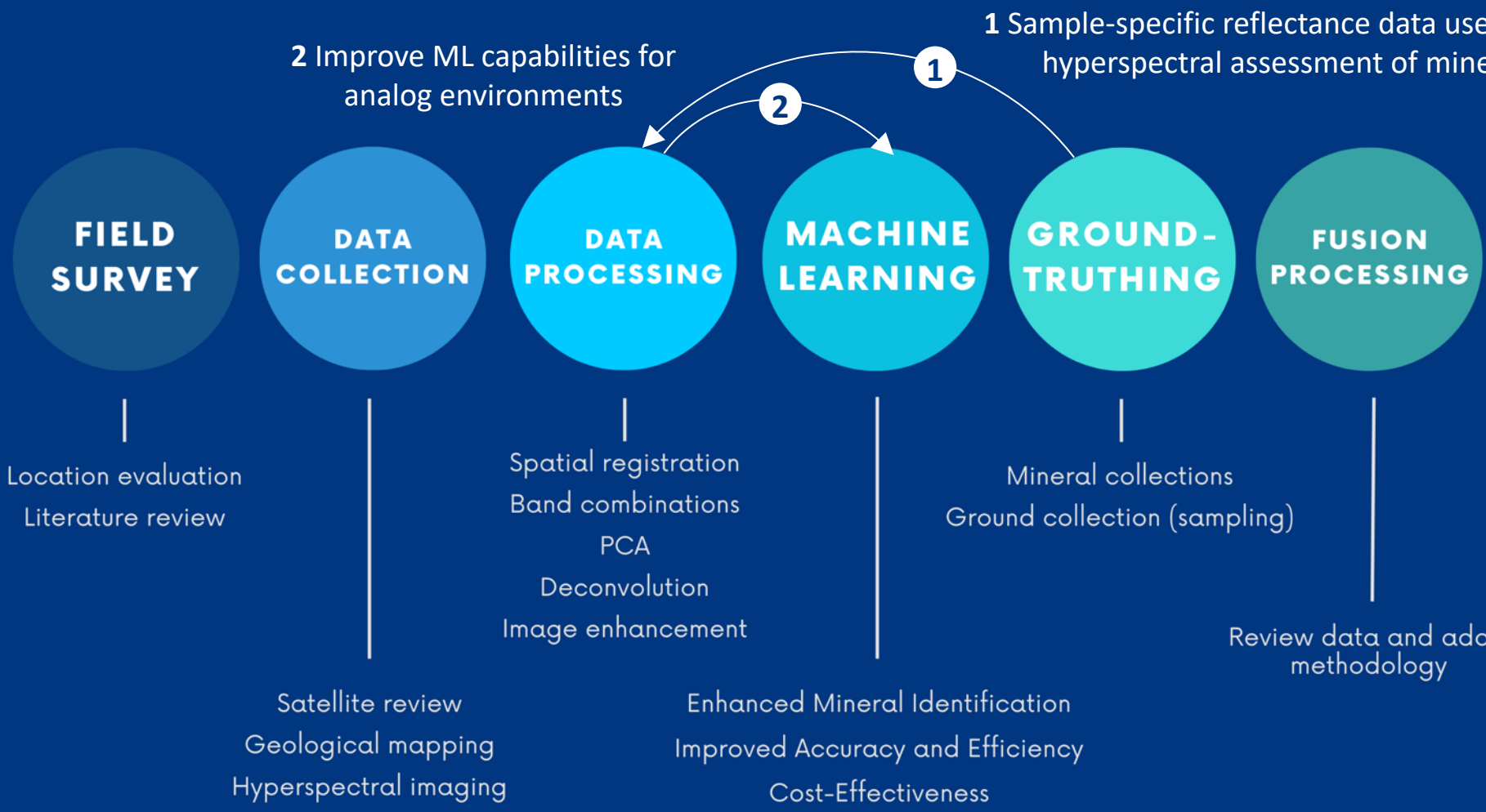

Satellite
Earth Surface
Along-track dimension built up by the motion of the satellite
Spectral Dimension
Spectral images taken simultaneously
Each image pixel contains a sampled spectrum which is used to identify the materials present in the pixel by their reflectance
Reflectance spectrum
Reflectance
Wavelength (nm)

METHODOLOGY

Example workflow from *Booysen et al.* 2022

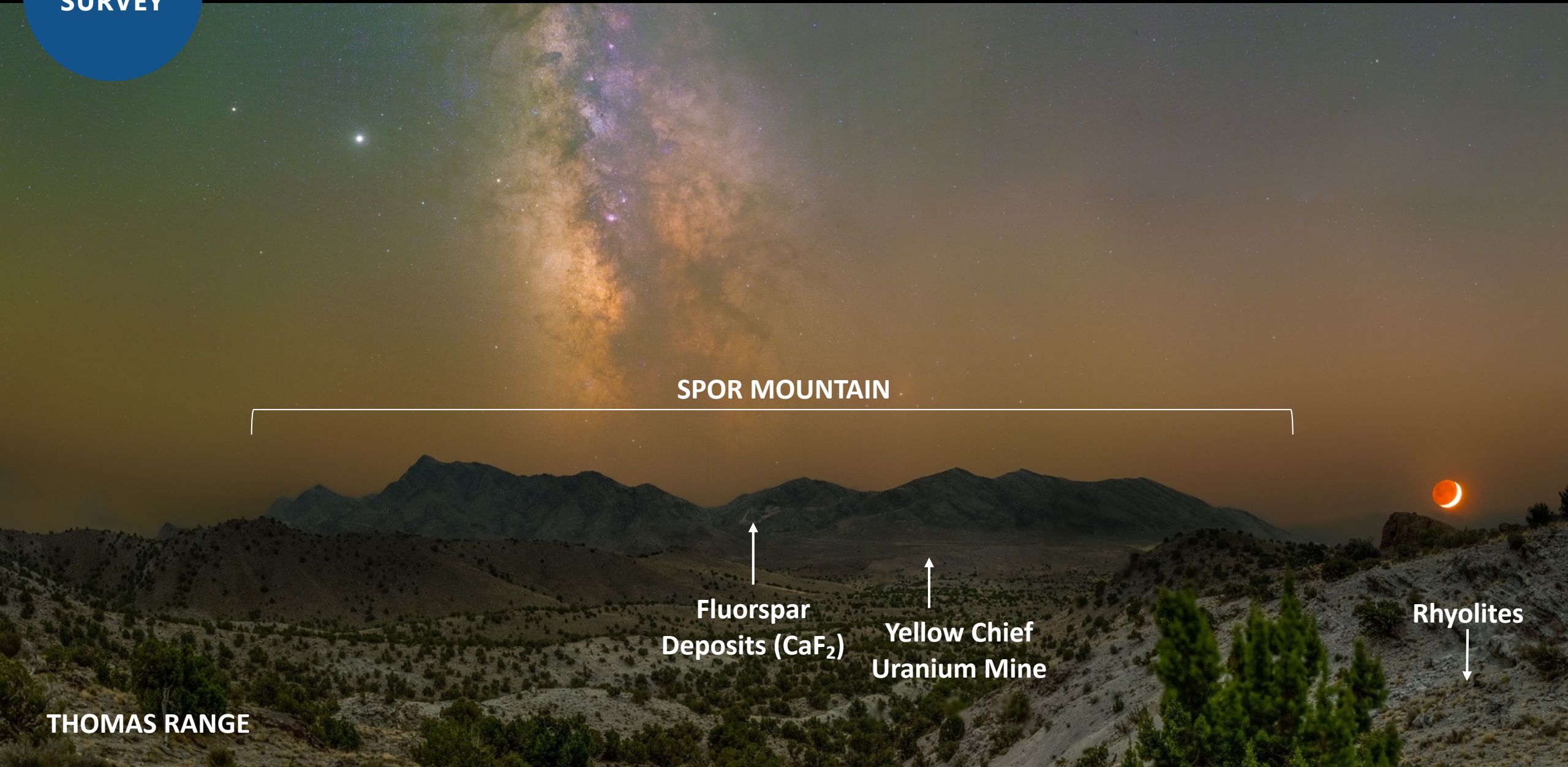


METHODOLOGY



FIELD SURVEY

SPOR MOUNTAIN, UTAH



FIELD SURVEY

AMERICA'S RELIANCE ON CRITICAL MINERALS

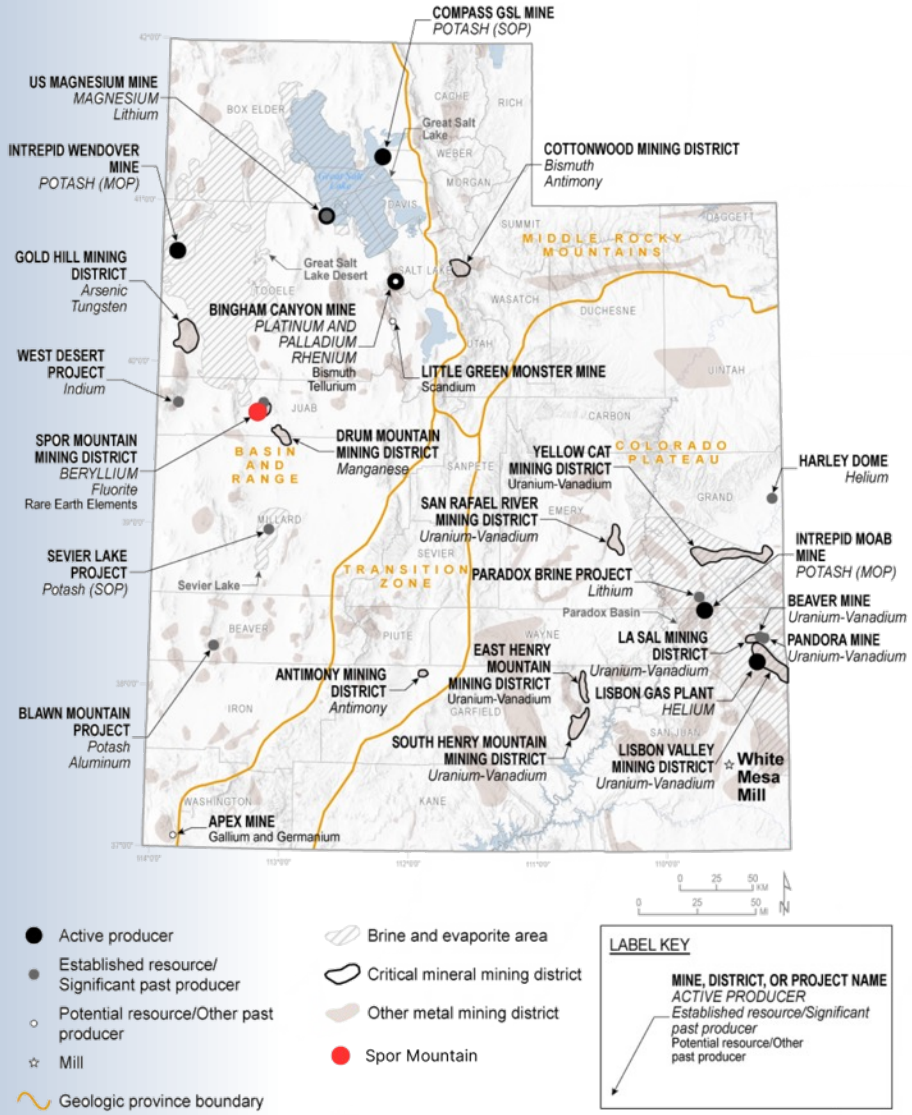
Mineralization Type: Epithermal, stratiform, disseminated replacement deposits in porous volcanic tuff at the half graben's base. Bertrandite mineralization primarily replaces carbonate clasts in the basal tuff.

➔ ***Possible hydrothermal spectral mapping***

Associated Elements: Beryllium mineralization linked with manganese (Mn) and enriched in elements like fluorine (F), uranium (U), lithium (Li), and rare earth elements (REE) such as Ce, Dy, Er, Gd, Ho, Nd, Sm, Y, and Yb.

Origin: Believed to result from hydrothermal fluids ascending from a deep-seated granitic pluton.

Source Hypothesis: Suggested that a rhyolite pluton near Eagle Rock Ridge may be the origin of Be, F, and U mineralization at Spor Mountain (Lindsey, 1982).



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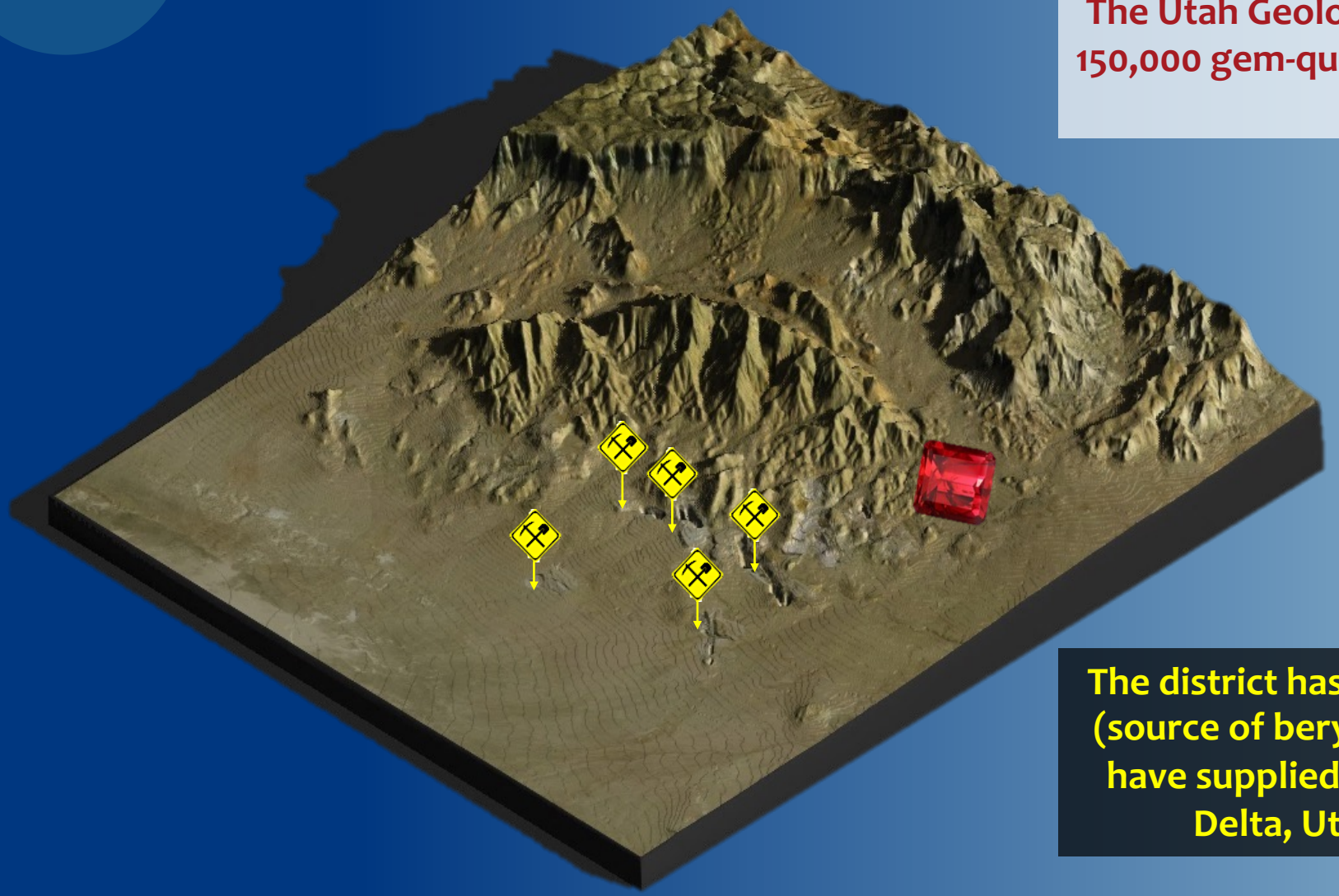
FIELD SURVEY

SPOR MOUNTAIN, UTAH



The Utah Geological Survey estimates that for every 150,000 gem-quality diamonds unearthed, one crystal of red beryl is found.

The district has a large concentration of Bertrandite (source of beryllium in the US). Five open-pit mines have supplied mill feed to a processing plant near Delta, Utah for approximately 15 years.

FIELD SURVEY

AMERICA'S RELIANCE ON CRITICAL MINERALS

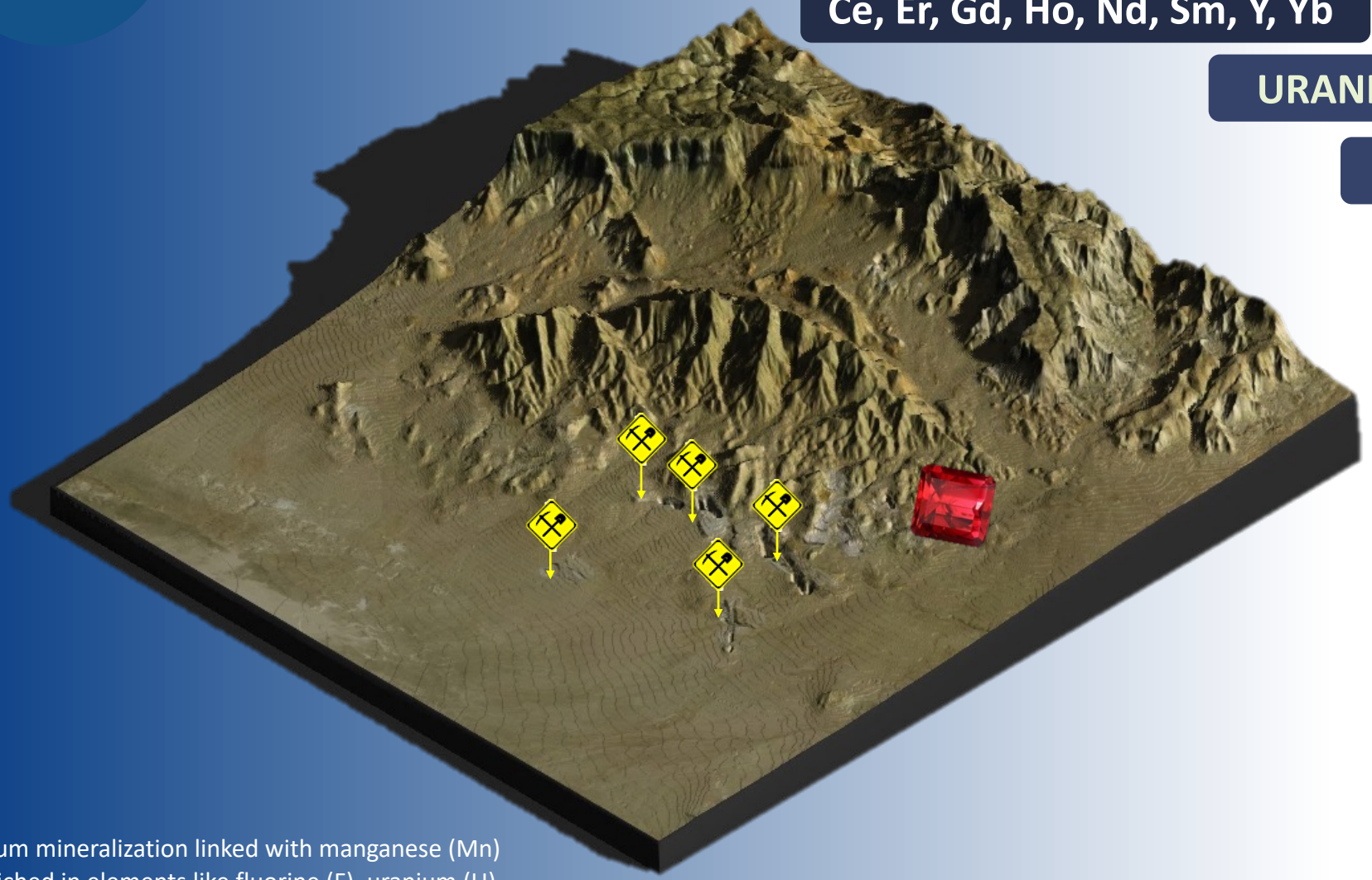
Ce, Er, Gd, Ho, Nd, Sm, Y, Yb

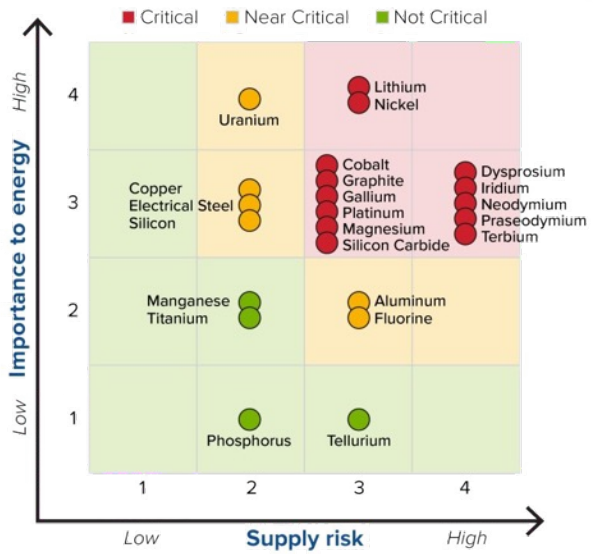
URANIUM

LITHIUM

DYSPROSIUM

BERYLLIUM





*Beryllium mineralization linked with manganese (Mn) and enriched in elements like fluorine (F), uranium (U), lithium (Li), and rare earth elements (REE) such as Ce, Dy, Er, Gd, Ho, Nd, Sm, Y, and Yb.

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FIELD SURVEY

WHY SPOR MOUNTAIN?

ENERGY

Ha Hafnium
Rh Rhenium
Ta Tantalum
U Uranium ★

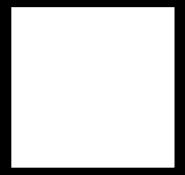
TECHNOLOGY

Ge Germanium
Id Indium
Ga Gallium
REE Rare earth elements ★
Nd Neodymium ★
Tb Terbium

INDUSTRIAL

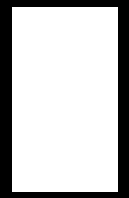
★
W Tungsten
Al Aluminum
PGMs Platinum Group Metals
(F) Fluorite
As Arsenic
Sc Scandium
Sr Strontium
Ti Titanium
(K) Potash
Dy Dysprosium ★
Ir Iridium

STEEL



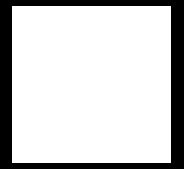
Mg Magnesium
Cr Chromium
S Tin
Te Tellurium
Mn Manganese
V Vanadium
Nb Niobium

BATTERIES



Li Lithium ★
Co Cobalt
Sb Antimony
(C) Graphite

RESEARCH



He Helium
Rb Rubidium
Ce Cesium ★
Bi Bismuth

METHODOLOGY

01 DEFINE STUDY AREA AND RESEARCH OBJECTIVES

Determine specific region for exploration and clarify target critical minerals. Understand geological context and potential mineralization models associated with the area.

02 ACQUIRE HYPERSPECTRAL DATA

Acquire hyperspectral data from appropriate satellite missions. Consider factors such as spatial resolution, spectral range, and revisit frequency when selecting the data acquisition platform.

03 PREPROCESS HYPERSPECTRAL DATA

Preprocessing steps to include a combination of atmospheric correction, geometric correction, and spectral resampling to a consistent spectral resolution in order to allow band combinations etc.

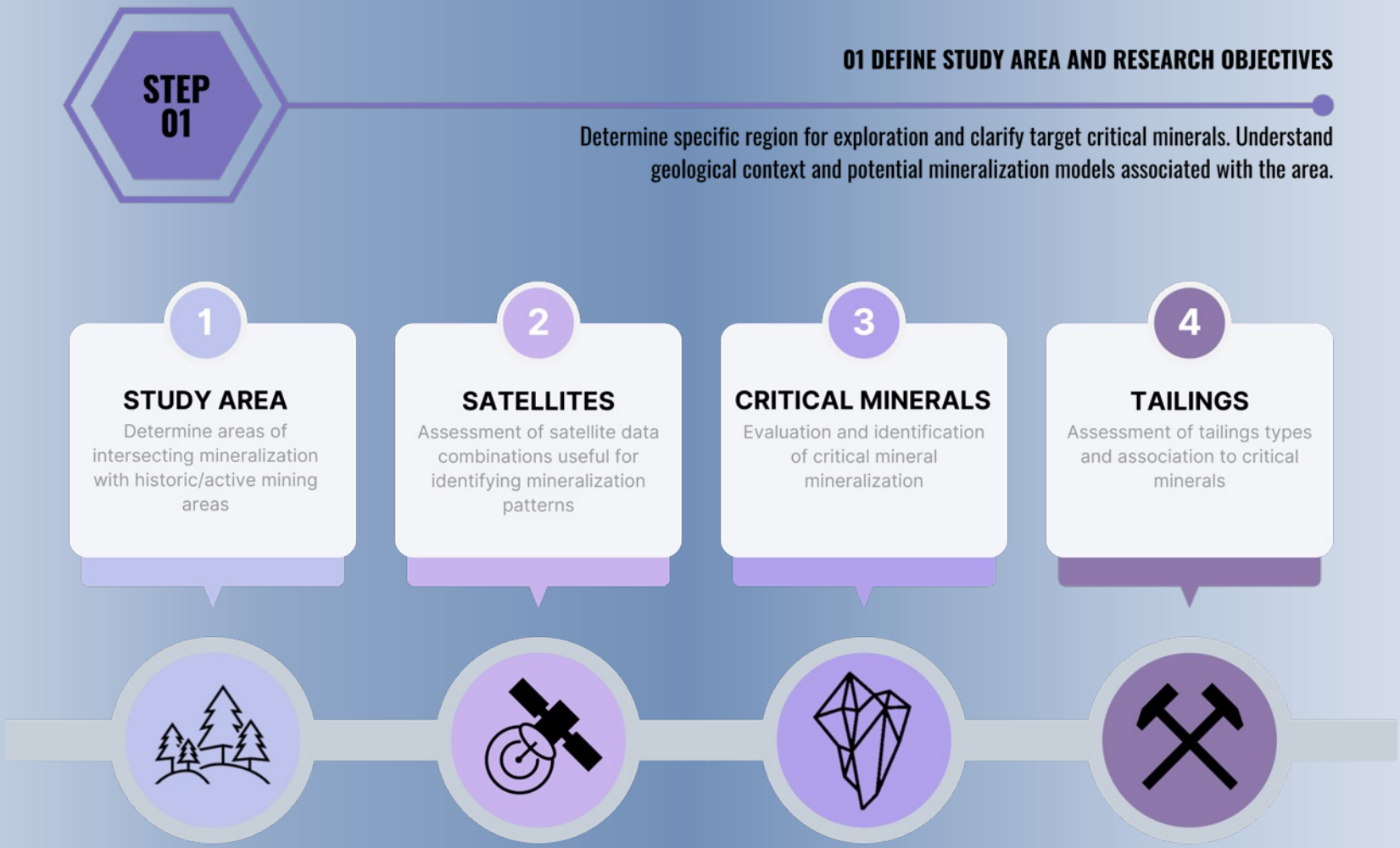
04 SPECTRAL ANALYSIS AND MINERAL IDENTIFICATION

Identify spectral signatures associated with critical minerals using spectral analysis techniques including: spectral un-mixing, band ratioing, or spectral feature extraction algorithms. Compare the spectral signatures obtained from the data with known spectral libraries of minerals to identify potential critical mineral occurrences.

05 GENERATE MINERAL MAPS AND ANOMALY DETECTION

Using identified mineral signatures, create maps highlighting areas with potential critical mineral occurrences. Utilize anomaly detection algorithms can help identify areas where the spectral properties deviate significantly from the background, indicating potential mineralization hotspots.

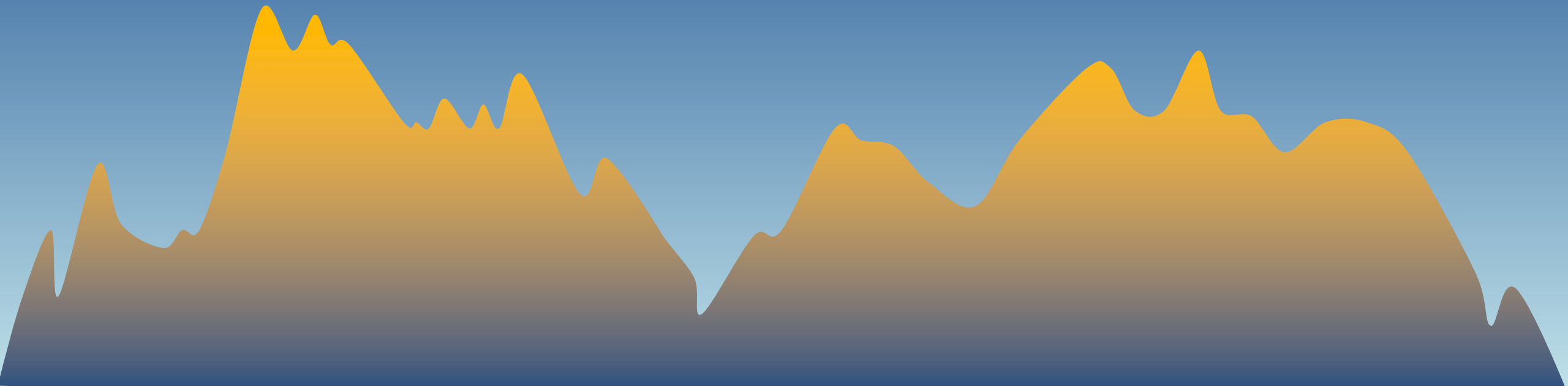
METHODOLOGY

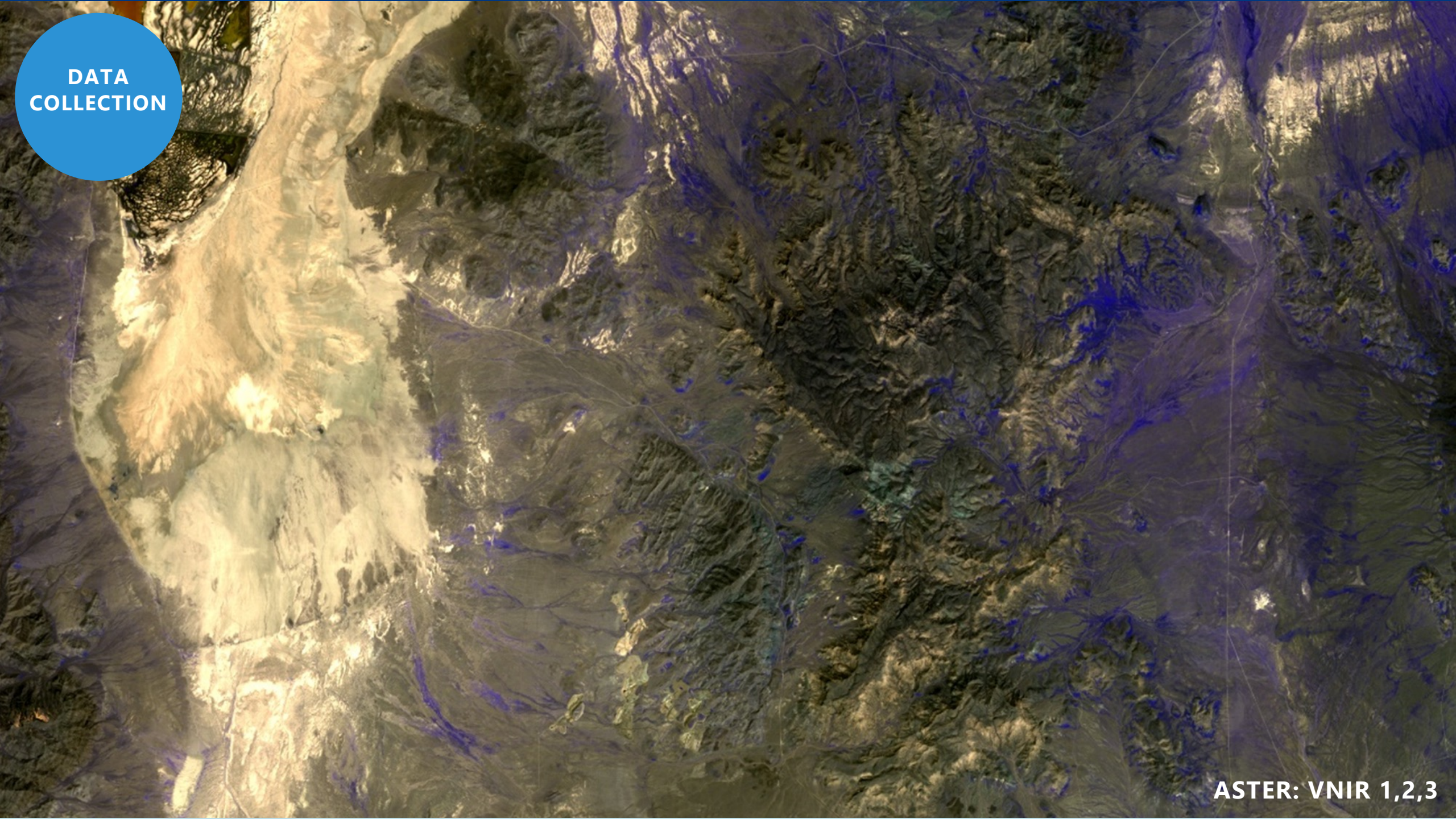


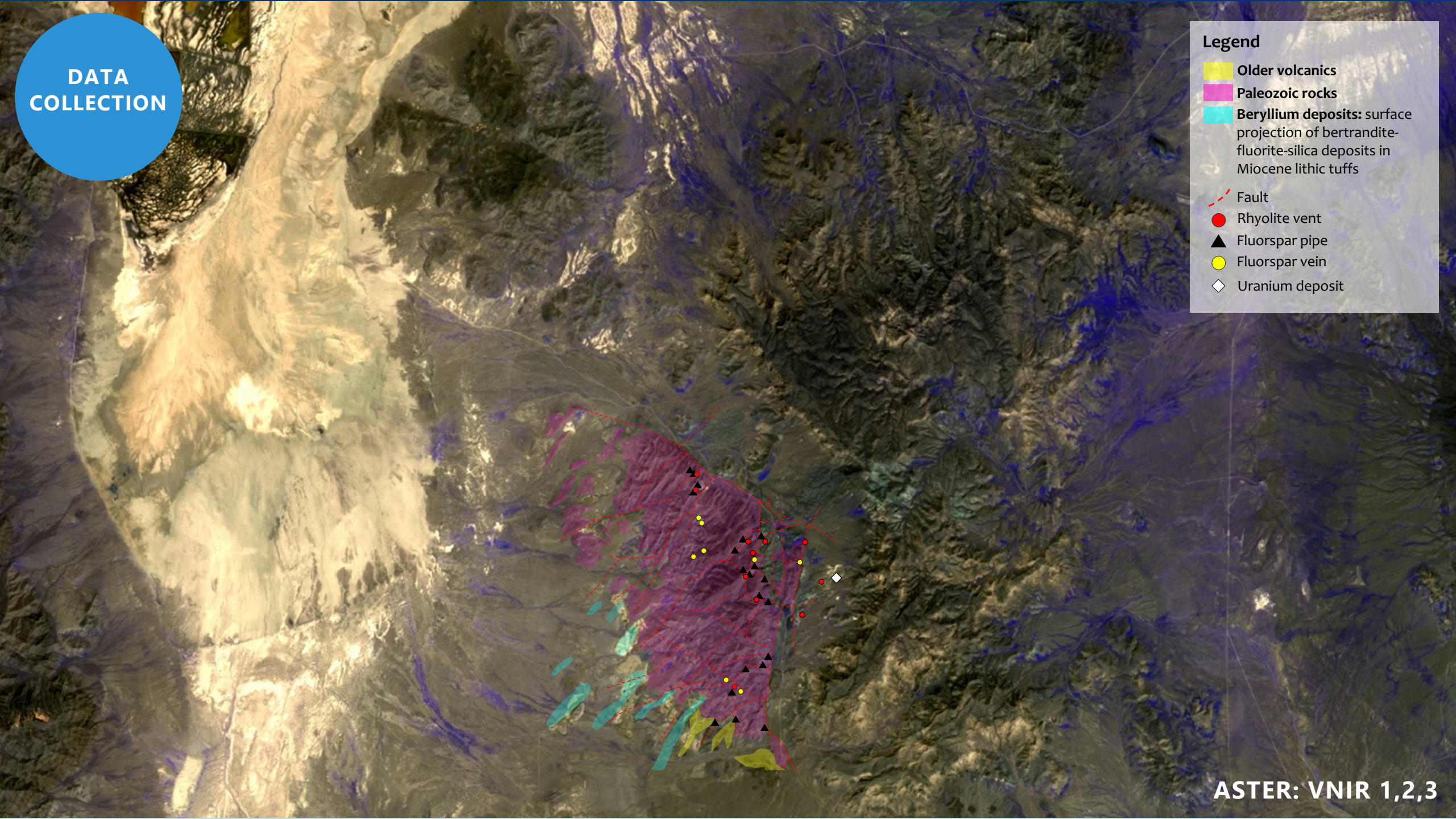
DATA COLLECTION

WHY SPOR MOUNTAIN?

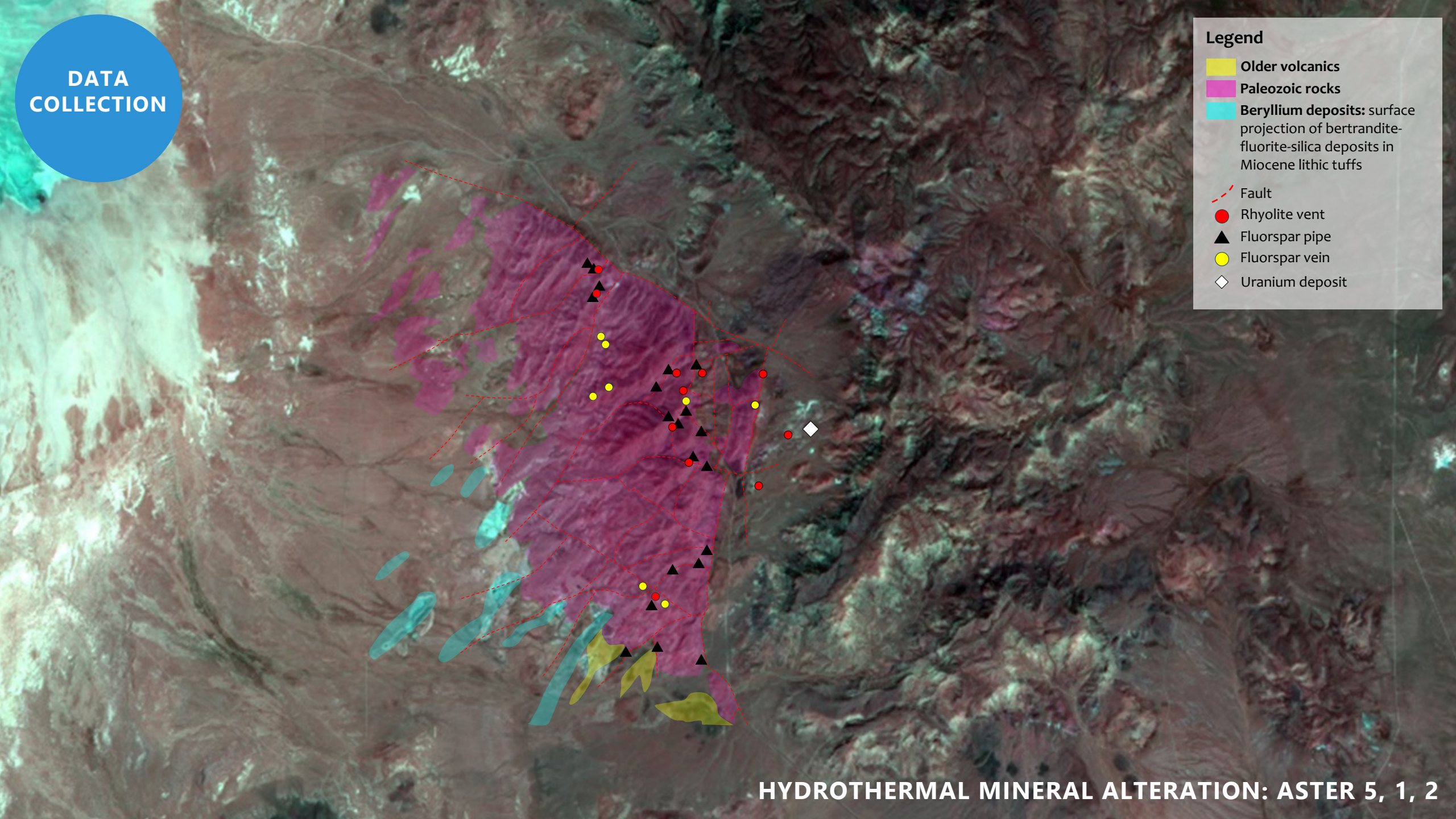
HYPERSPECTRAL IMAGING ANALYSIS




DATA
COLLECTION
ASTER: VNIR 1,2,3

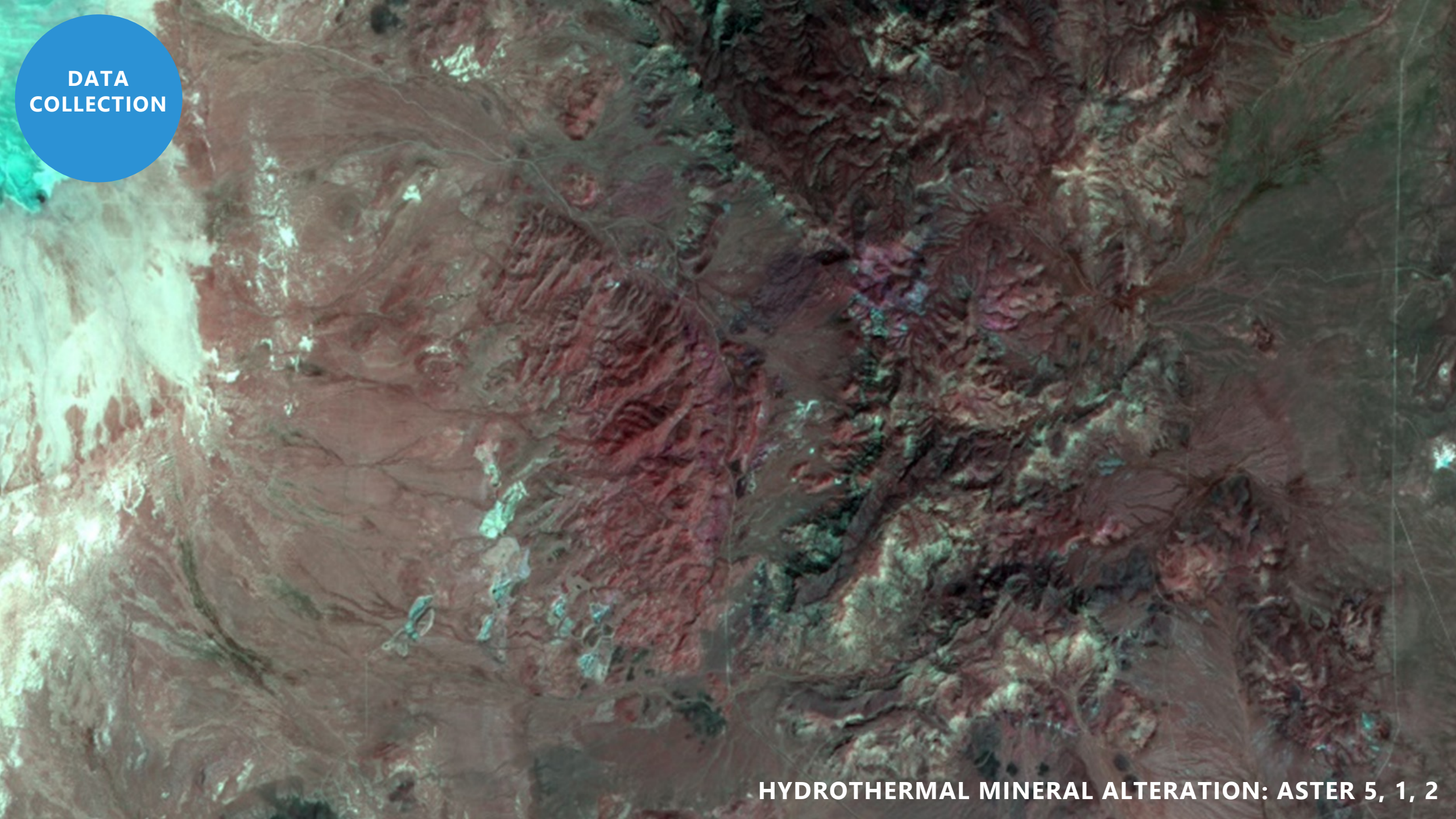

DATA COLLECTION
Legend
Older volcanics
Paleozoic rocks
Beryllium deposits: surface projection of bertrandite-fluorite-silica deposits in Miocene lithic tuffs
Fault
Rhyolite vent
Fluorspar pipe
Fluorspar vein
Uranium deposit
ASTER: VNIR 1,2,3

DATA COLLECTION



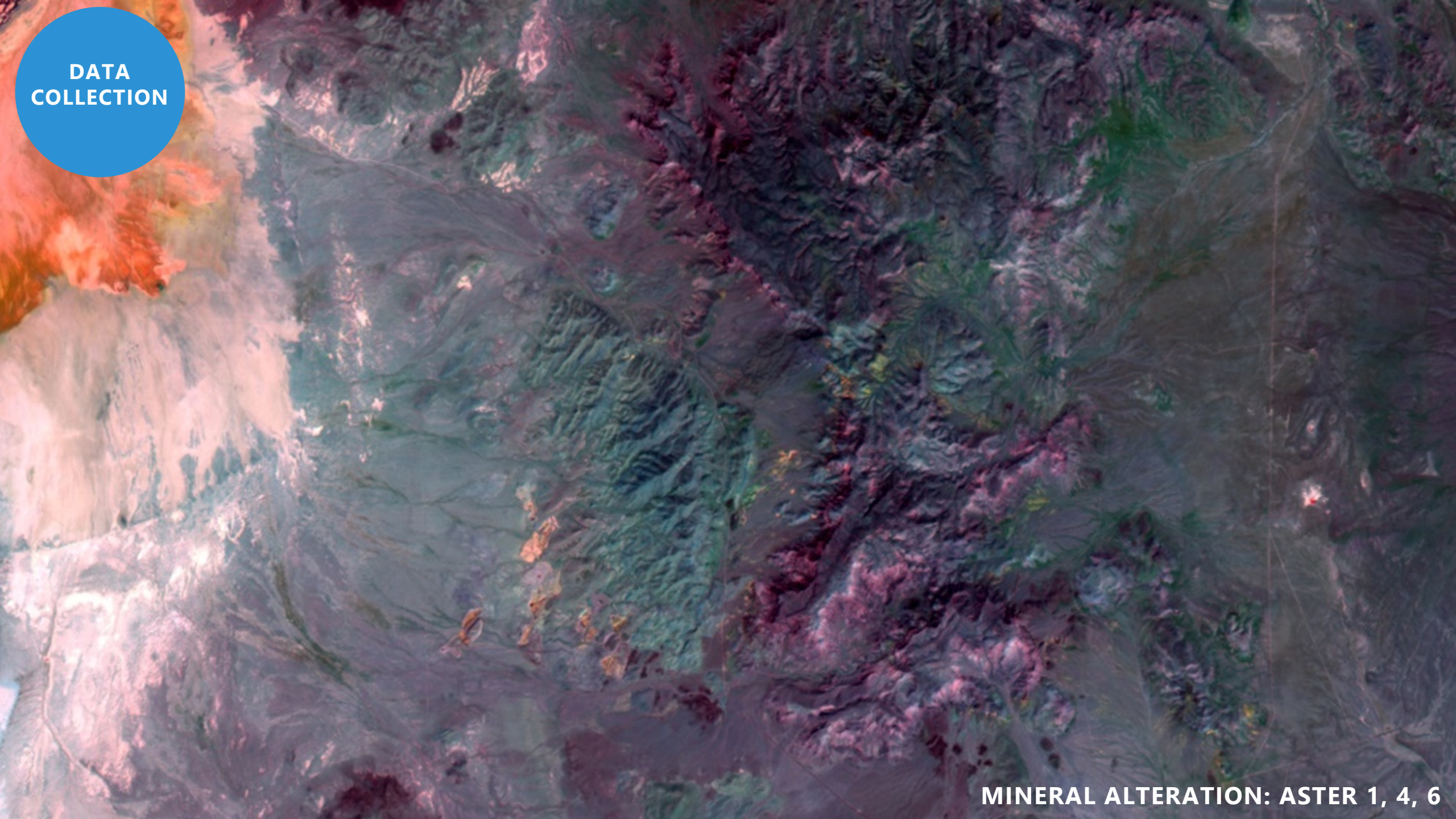
HYDROTHERMAL MINERAL ALTERATION: ASTER 5, 1, 2

DATA COLLECTION



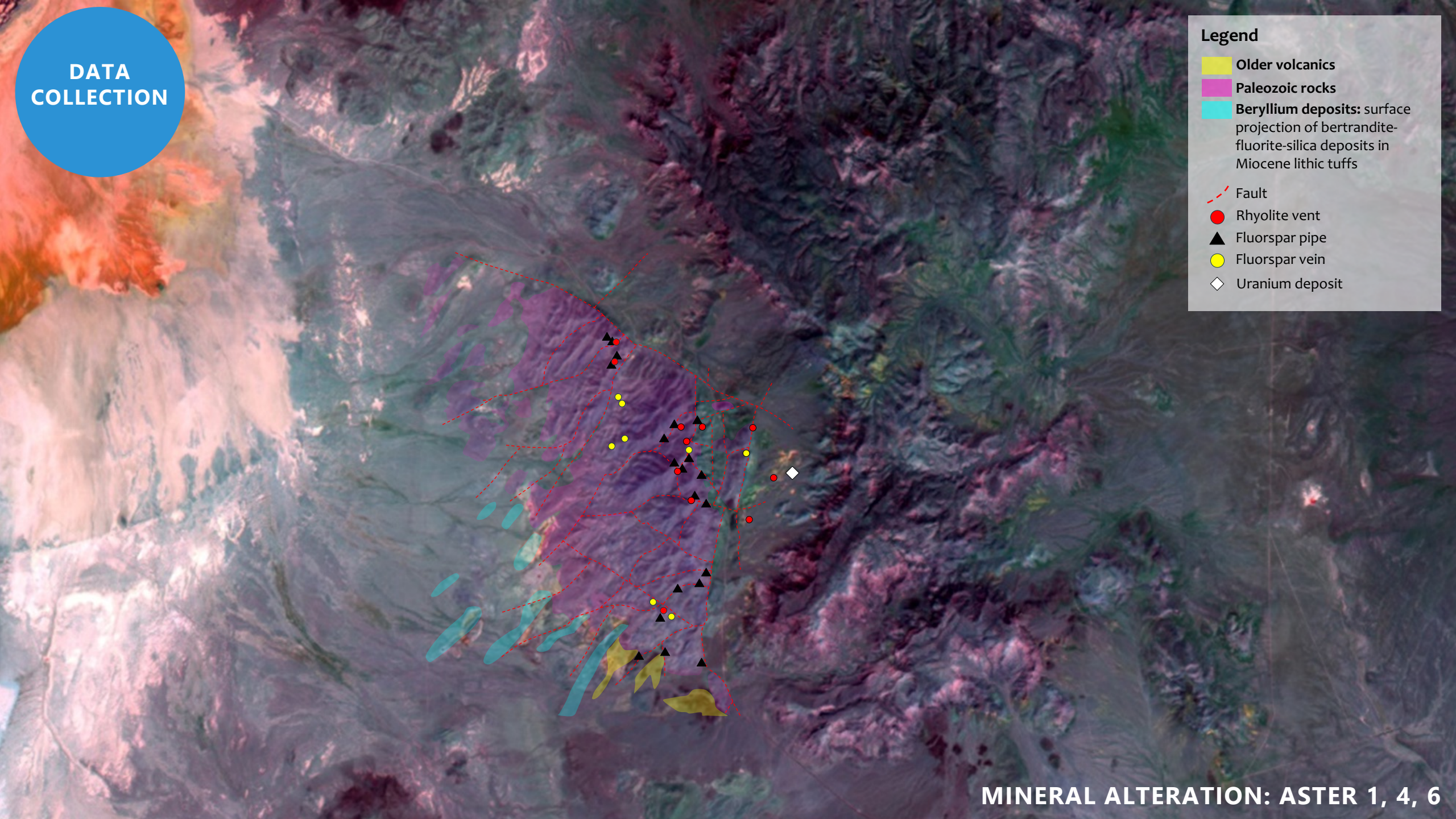
HYDROTHERMAL MINERAL ALTERATION: ASTER 5, 1, 2

DATA COLLECTION



MINERAL ALTERATION: ASTER 1, 4, 6

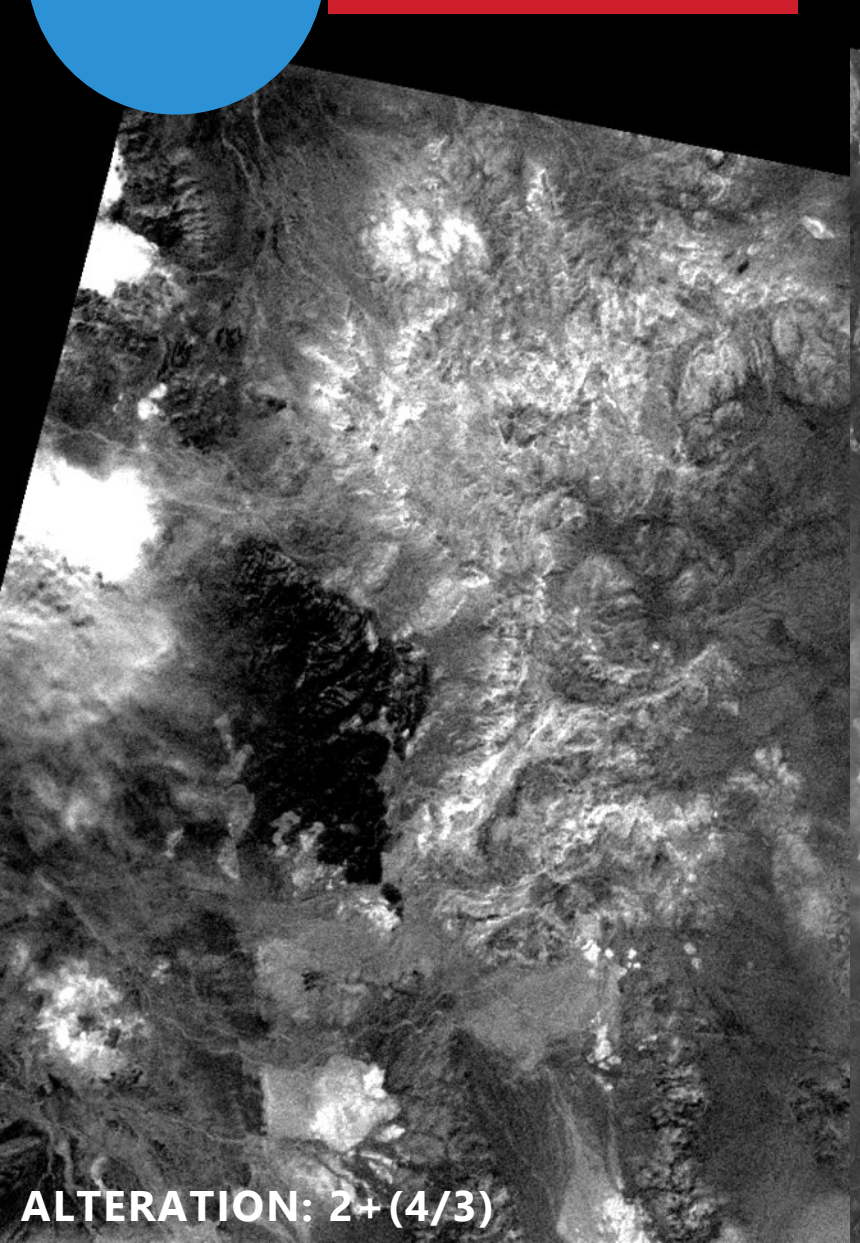
DATA COLLECTION



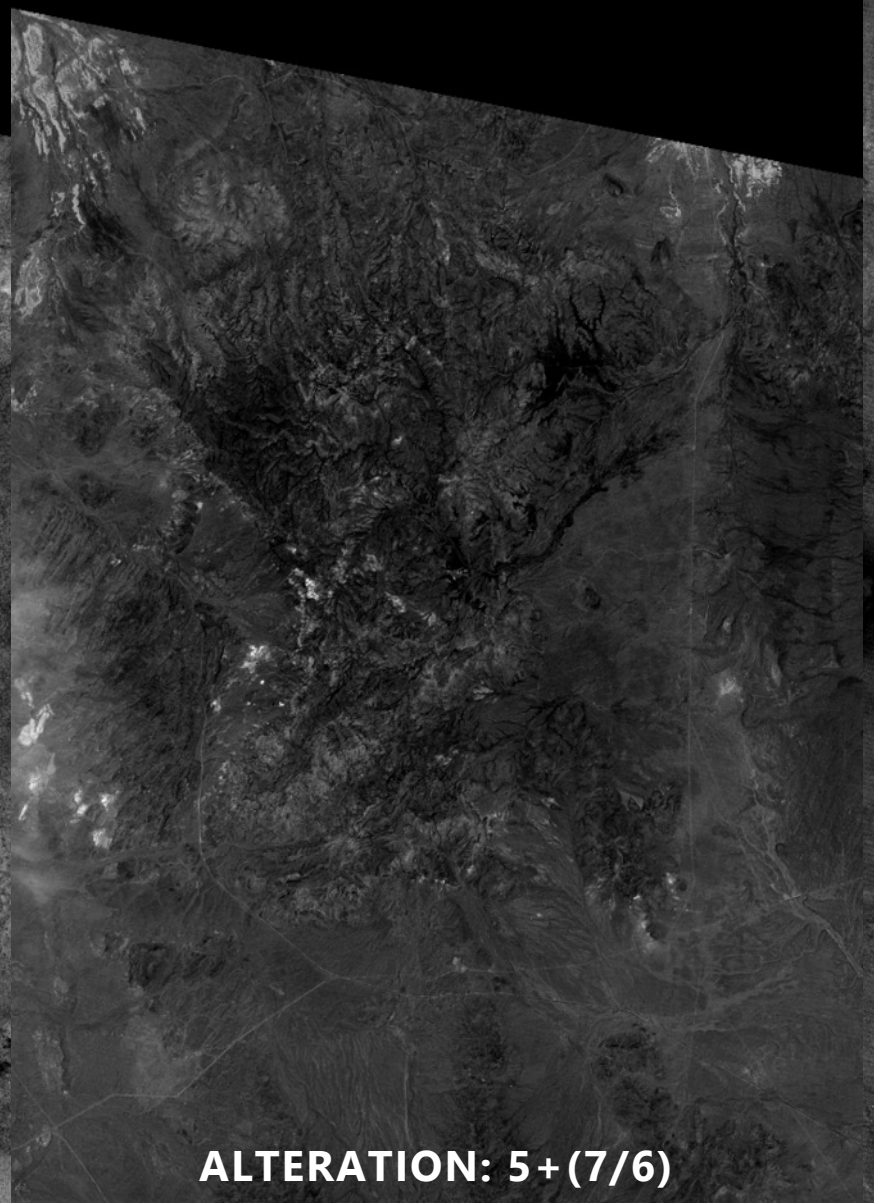
MINERAL ALTERATION: ASTER 1, 4, 6

DATA COLLECTION

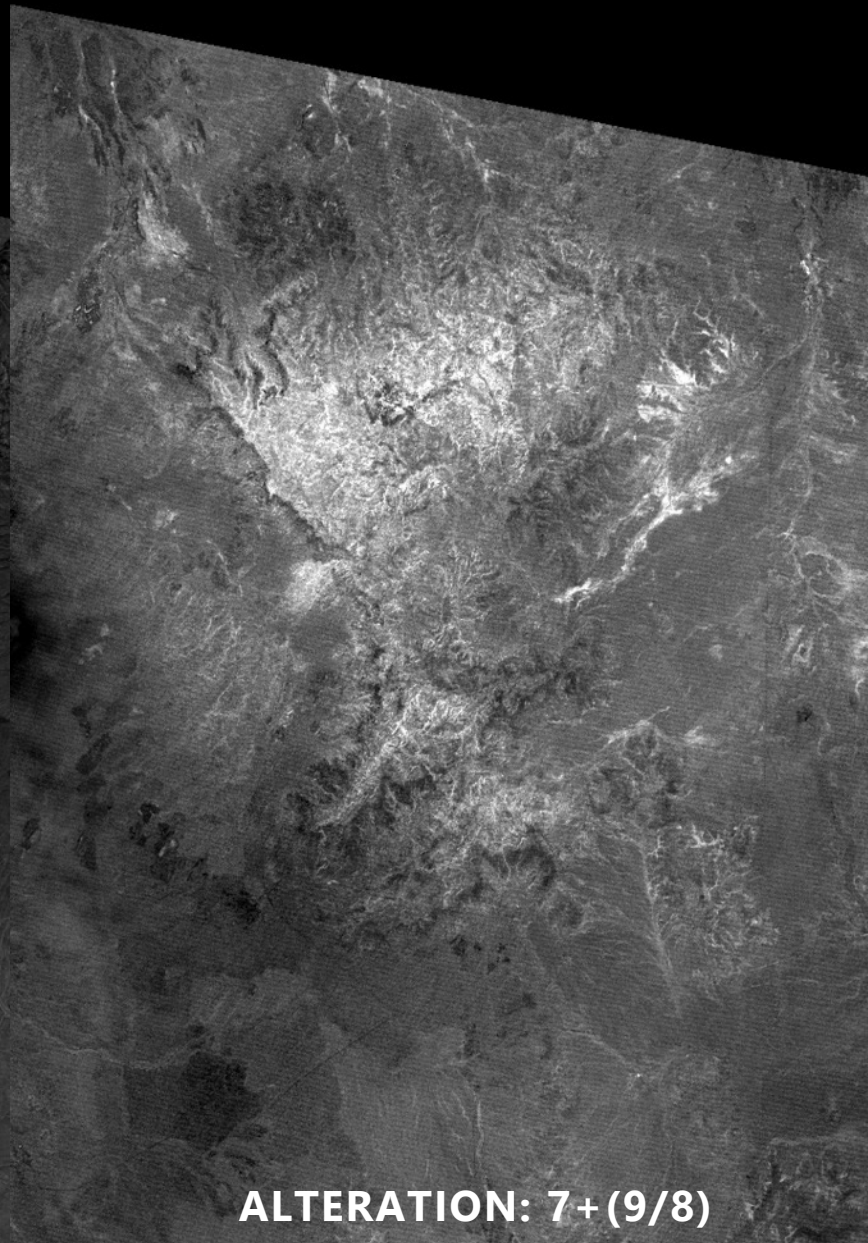
Alteration RGB Aster Imaging



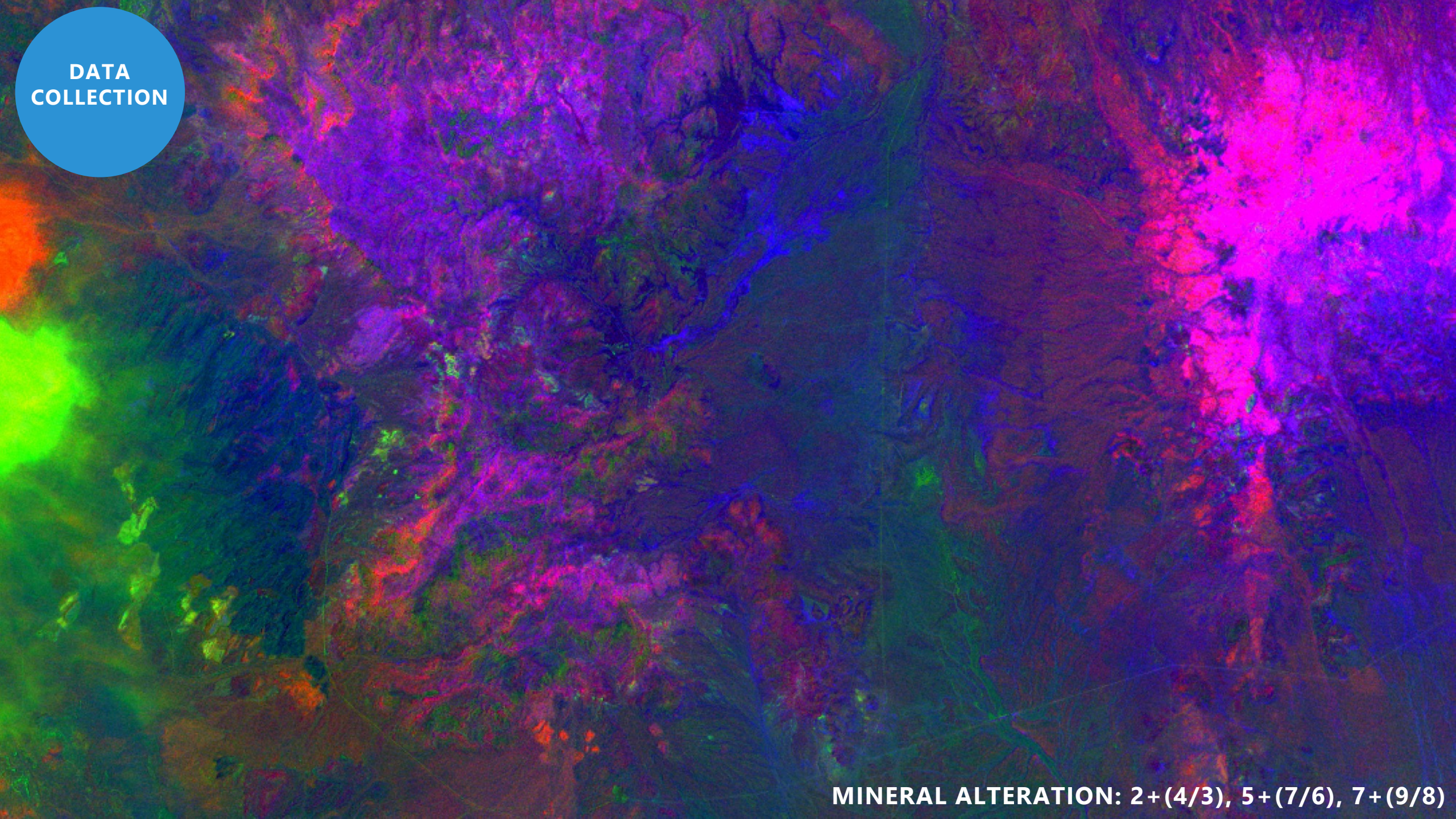
ALTERATION: 2+(4/3)



ALTERATION: 5+(7/6)

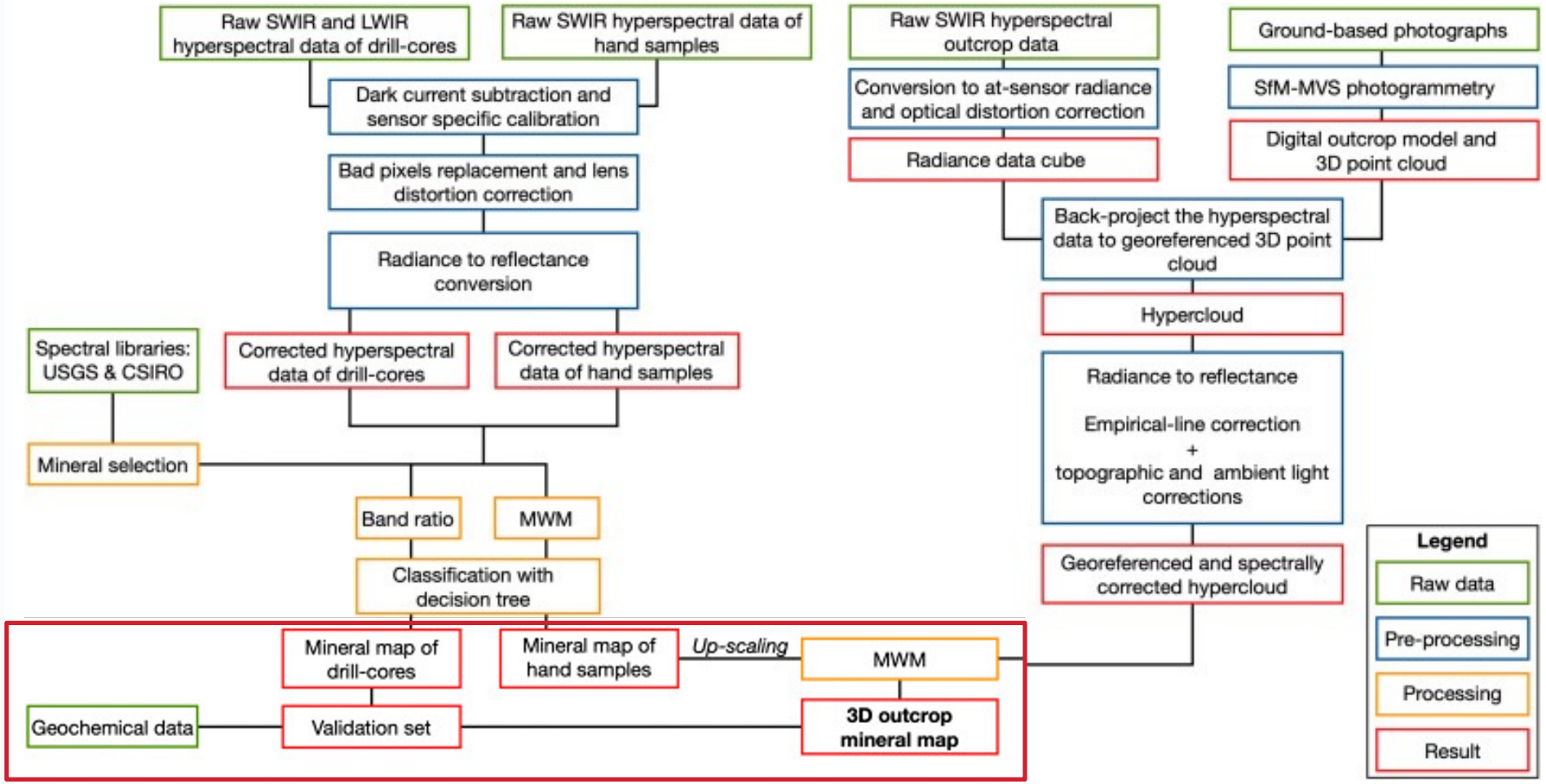


ALTERATION: 7+(9/8)


DATA
COLLECTION
MINERAL ALTERATION: 2+(4/3), 5+(7/6), 7+(9/8)

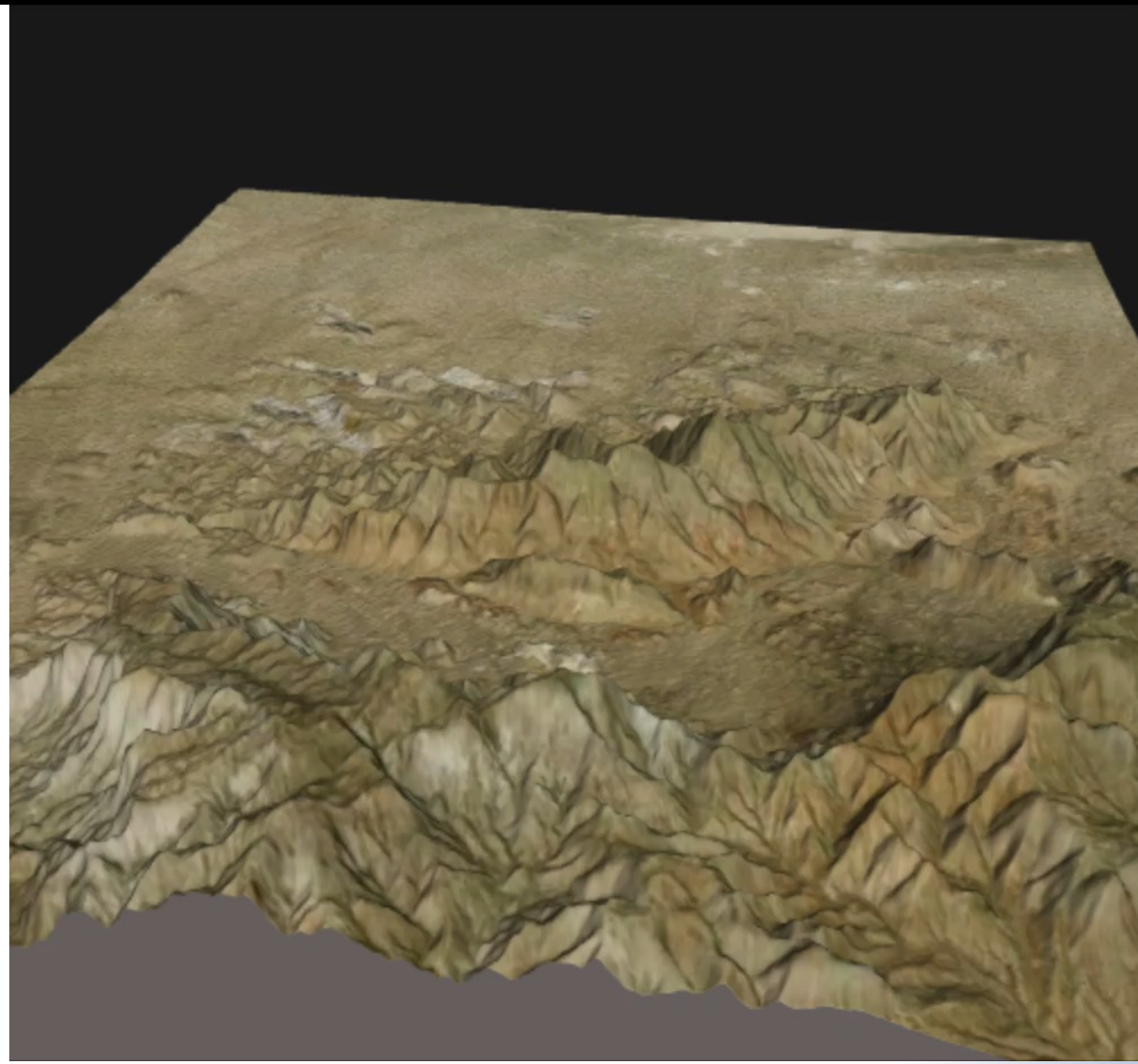
NEXT STEPS

Example workflow from *Booysen et al. 2022*



NEXT STEPS

- Dataset analysis
- Reflectance data per-pixel analysis
- Target detection
- Utilize other satellites: PRISMA, Sentinel-2, Worldview



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