



Energy & Geoscience Institute
AT THE UNIVERSITY OF UTAH



Hyperspectral Imaging: Spor Mountain Critical Minerals Evaluation

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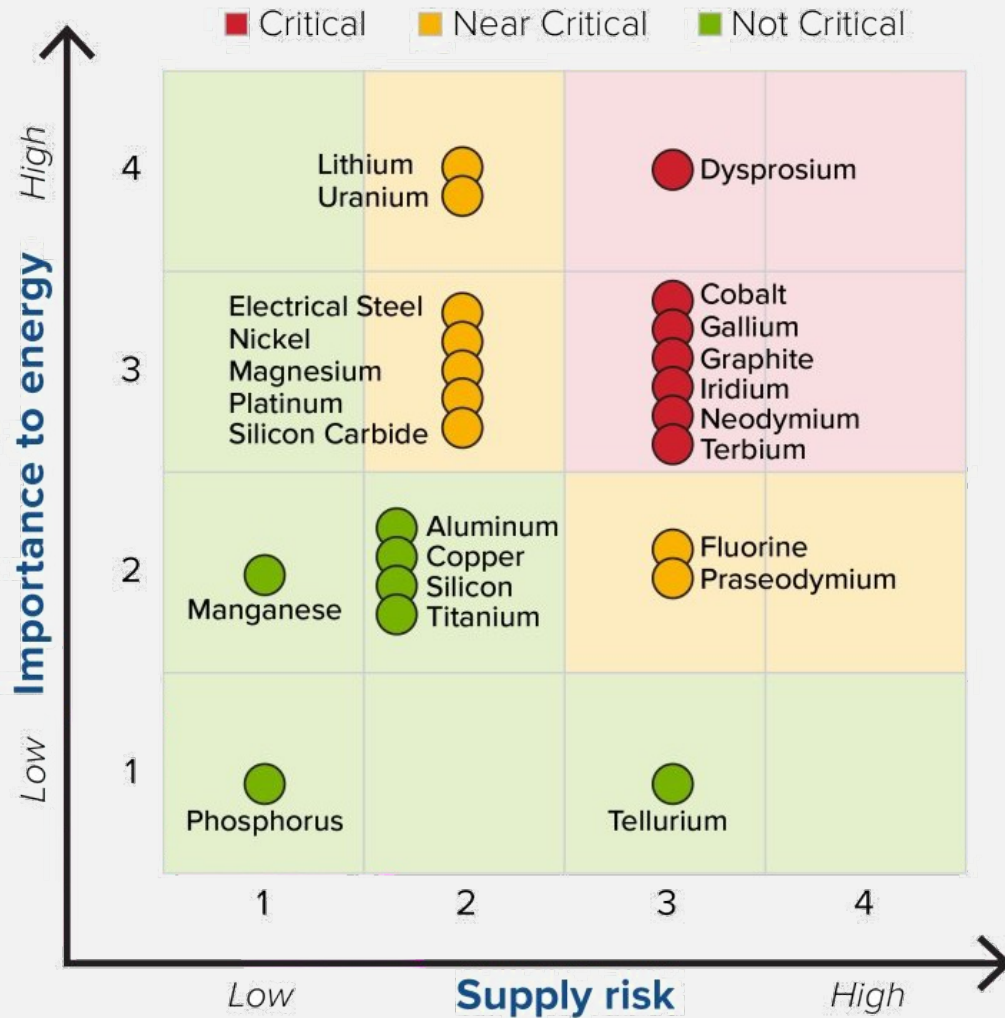
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AMERICA'S RELIANCE ON CRITICAL MINERALS

SHORT TERM 2020-2025



MEDIUM TERM 2025-2035



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

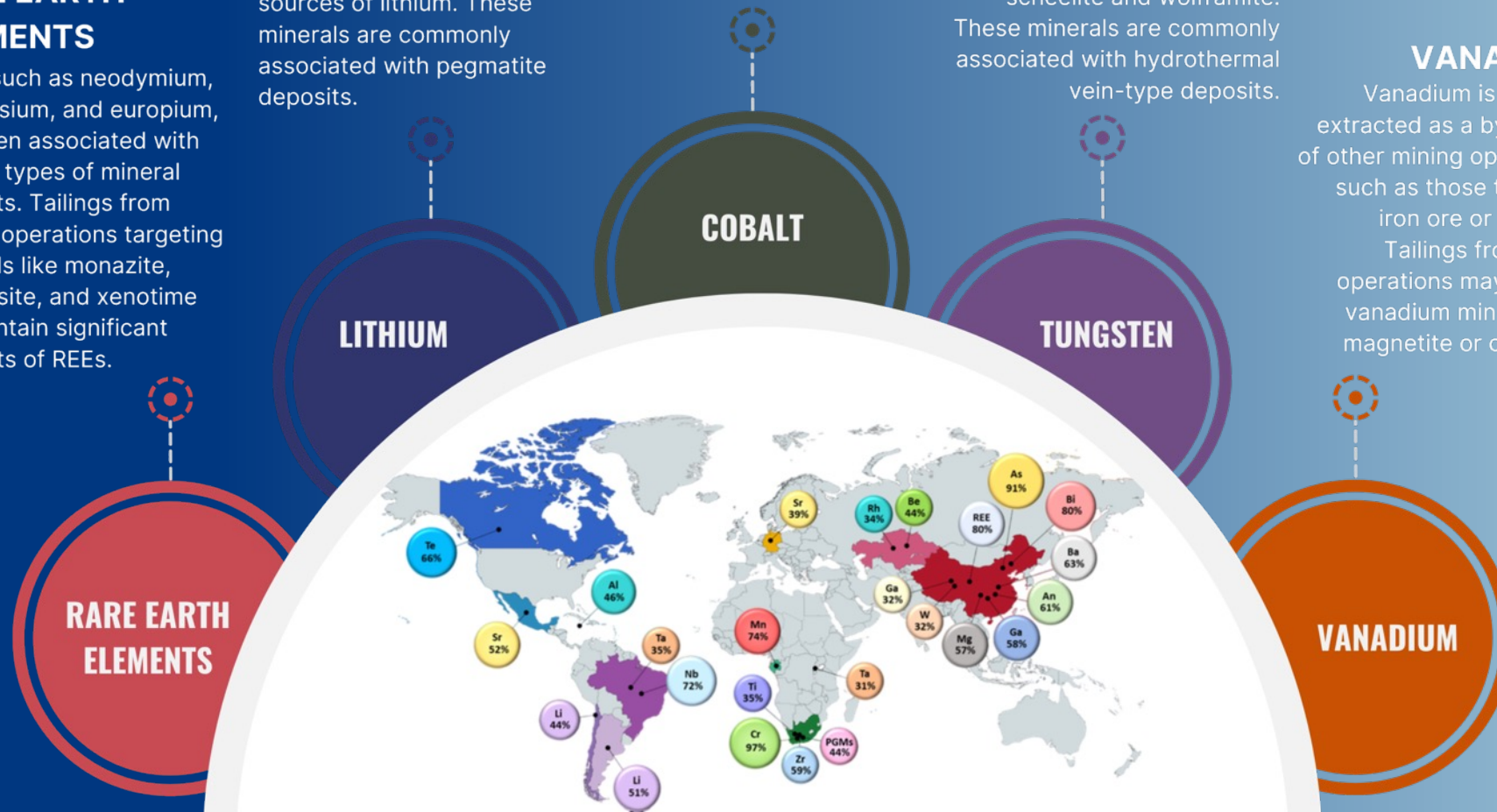
Cobalt is often found as a byproduct of copper and nickel mining. Tailings from copper and nickel operations, particularly those targeting sulfide ores, may contain cobalt as well.

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.



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:

**FIELD
SURVEY**

**DATA
COLLECTION**

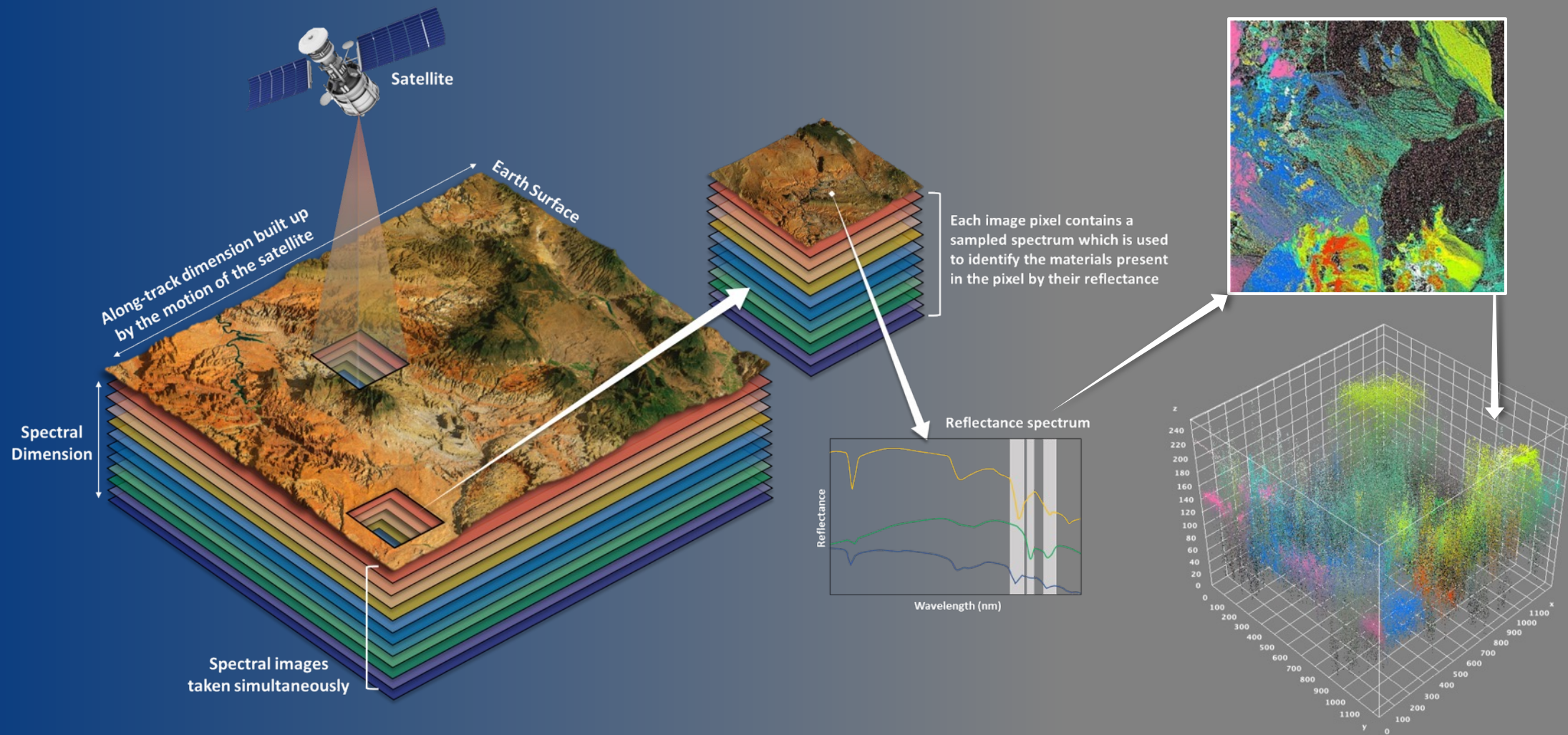
**DATA
PROCESSING**

**MACHINE
LEARNING**

**GROUND-
TRUTHING**

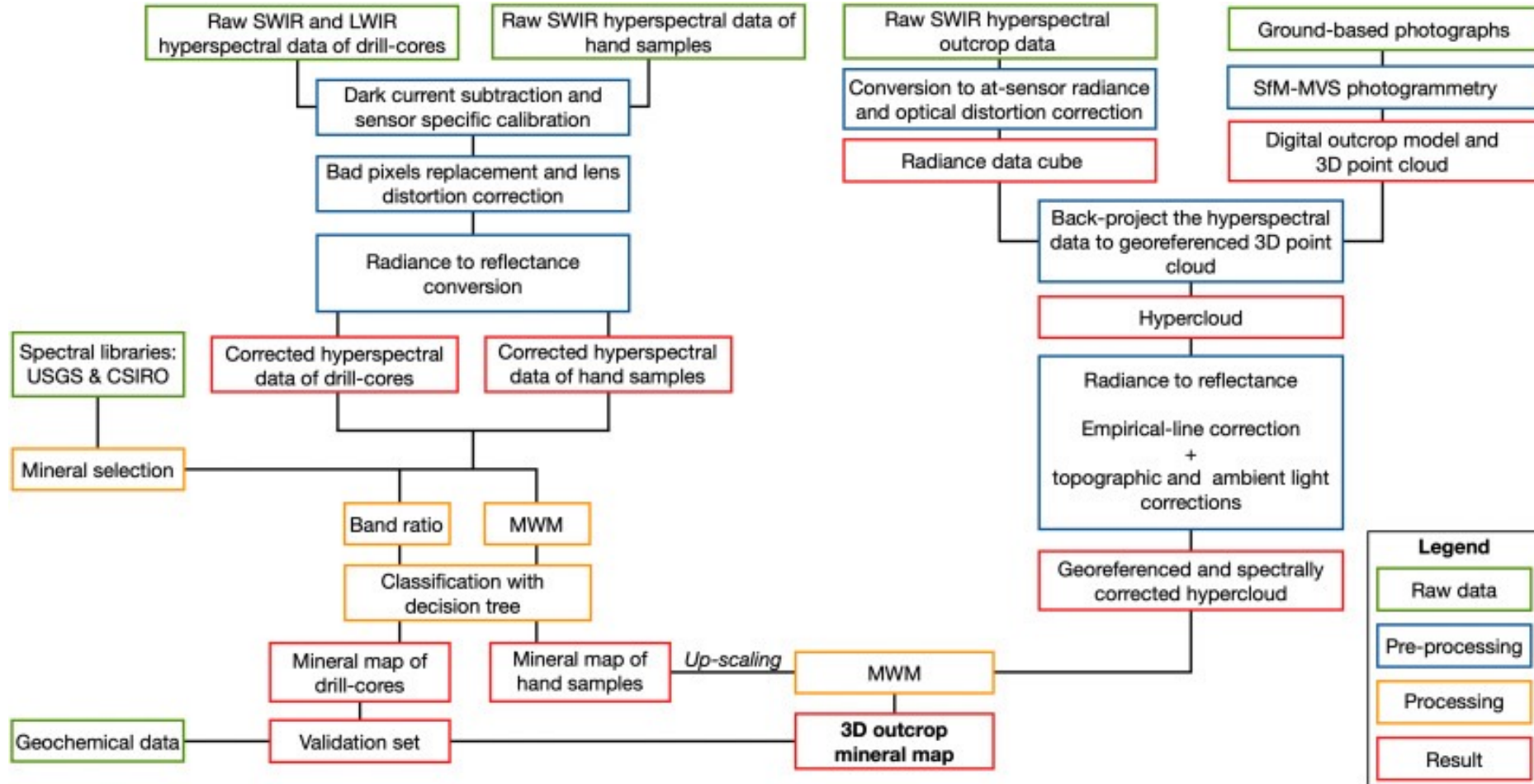
**FUSION
PROCESSING**

IMAGING 101

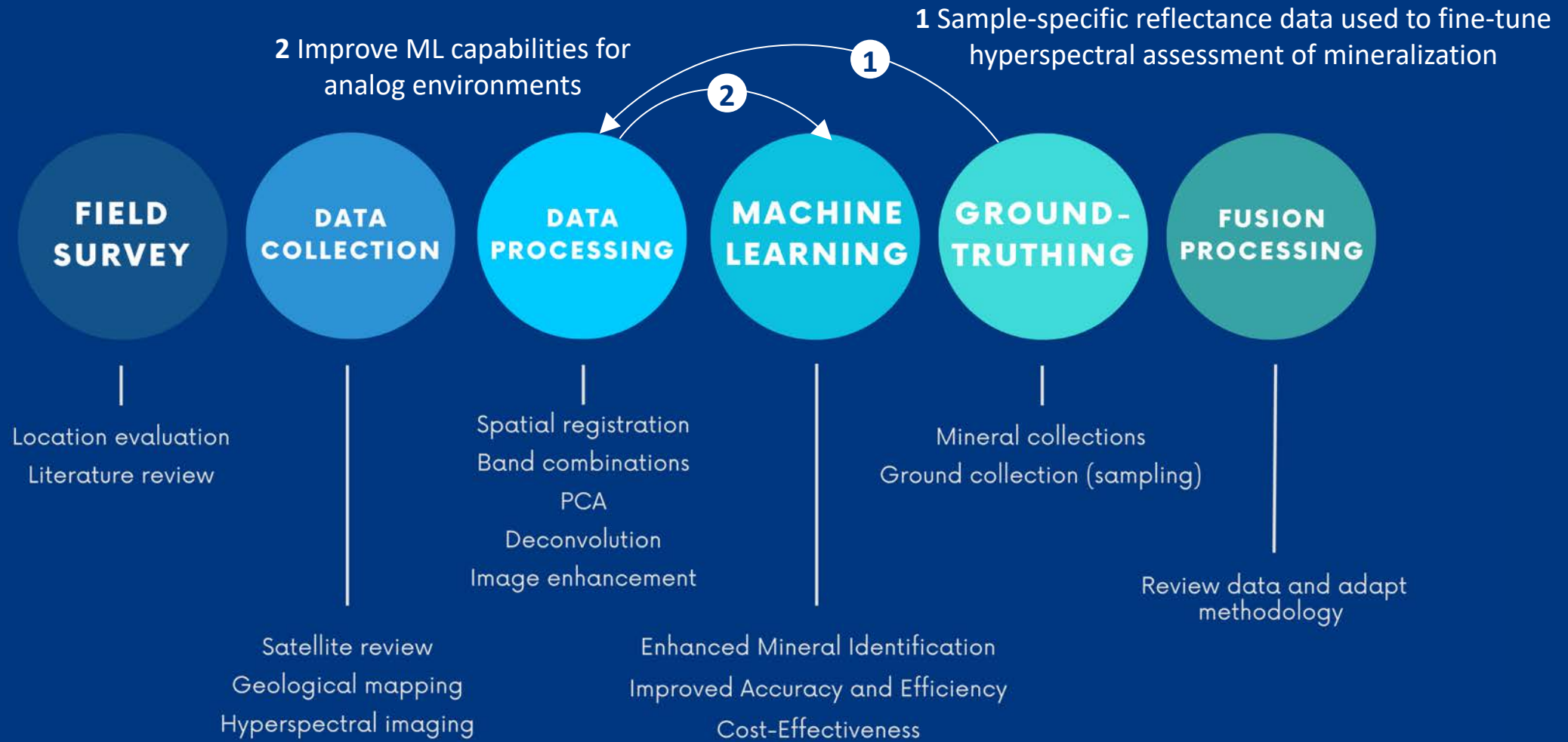


METHODOLOGY

Example workflow from Booyesen et al. 2022



METHODOLOGY



SPOR MOUNTAIN, UTAH

FIELD
SURVEY

SPOR MOUNTAIN

Fluorspar
Deposits (CaF_2)

Yellow Chief
Uranium Mine

Rhyolites

THOMAS RANGE

AMERICA'S RELIANCE ON CRITICAL MINERALS

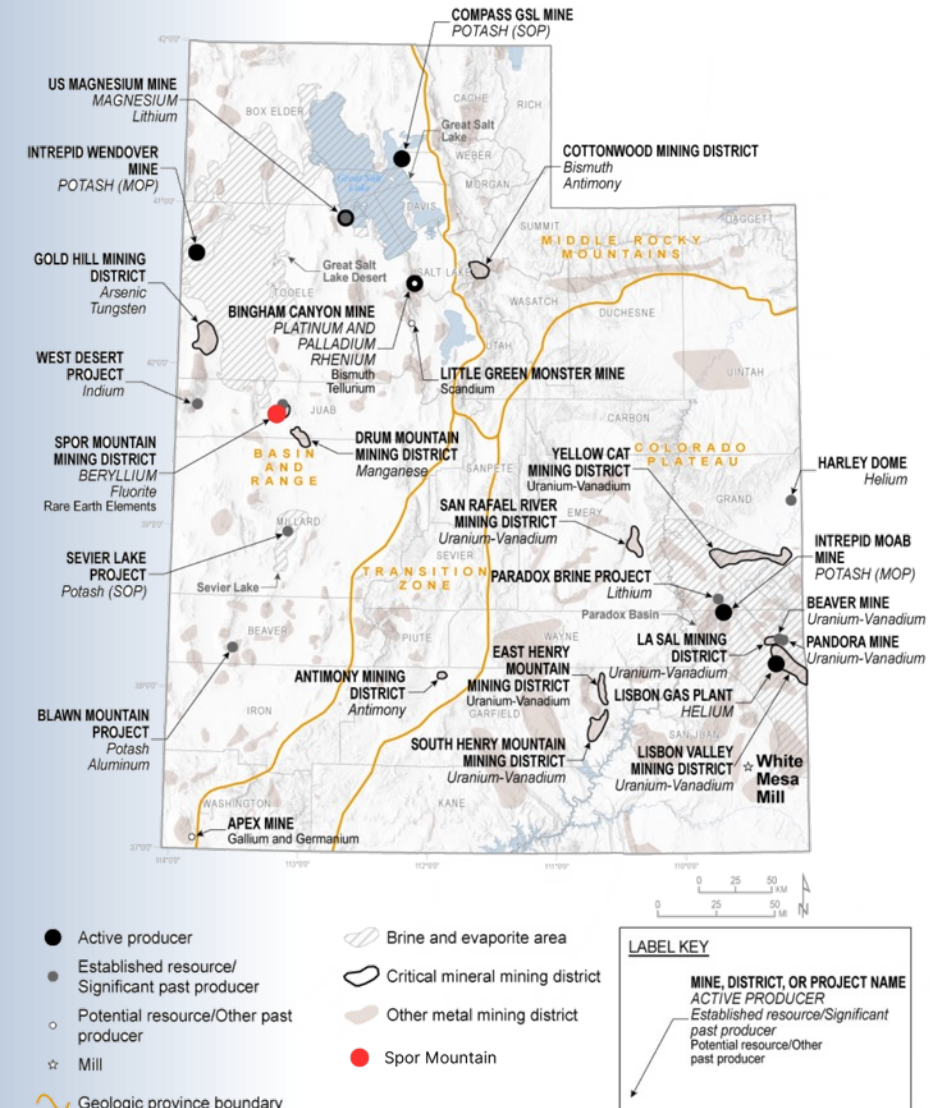
Mineralization Type: Epithermal, stratiform, disseminated replacement deposits in porous volcanic tuff at the half graben's base. Bertrandite mineralization primarily replaces carbonate clasts in the basal tuff.

➔ **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.

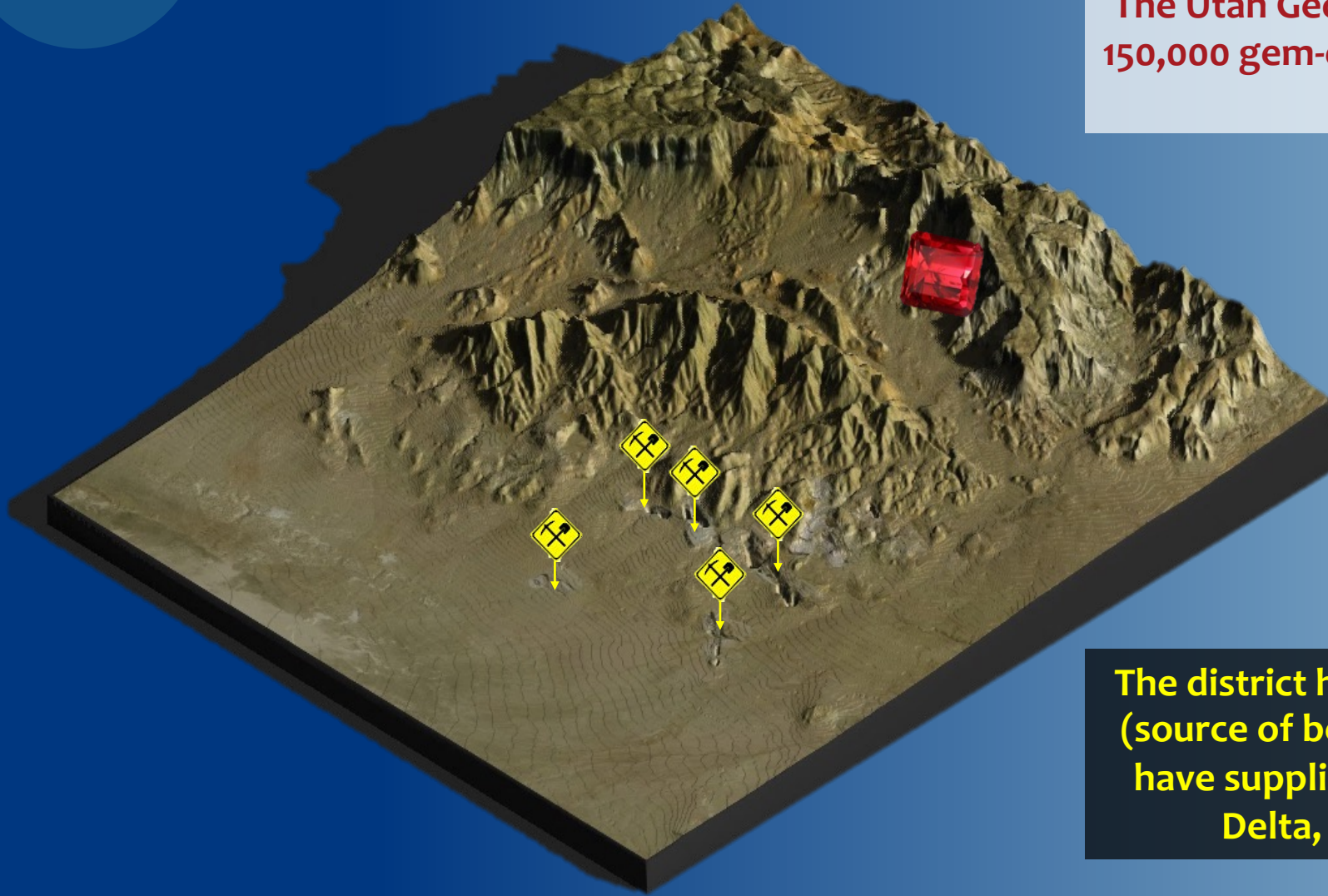
Origin: Believed to result from hydrothermal fluids ascending from a deep-seated granitic pluton.

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).



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.

AMERICA'S RELIANCE ON CRITICAL MINERALS

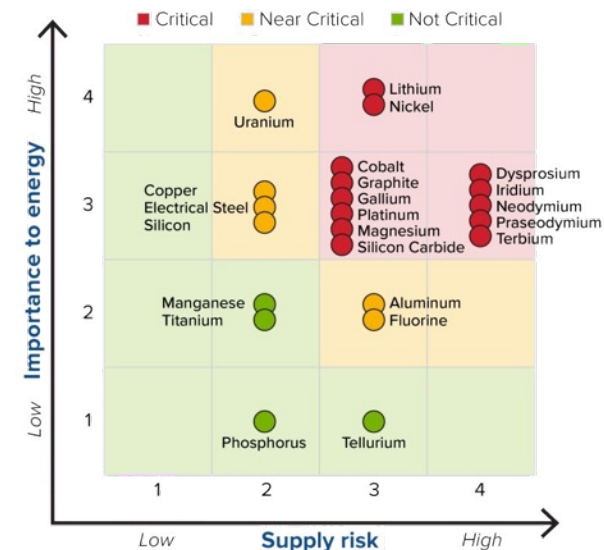
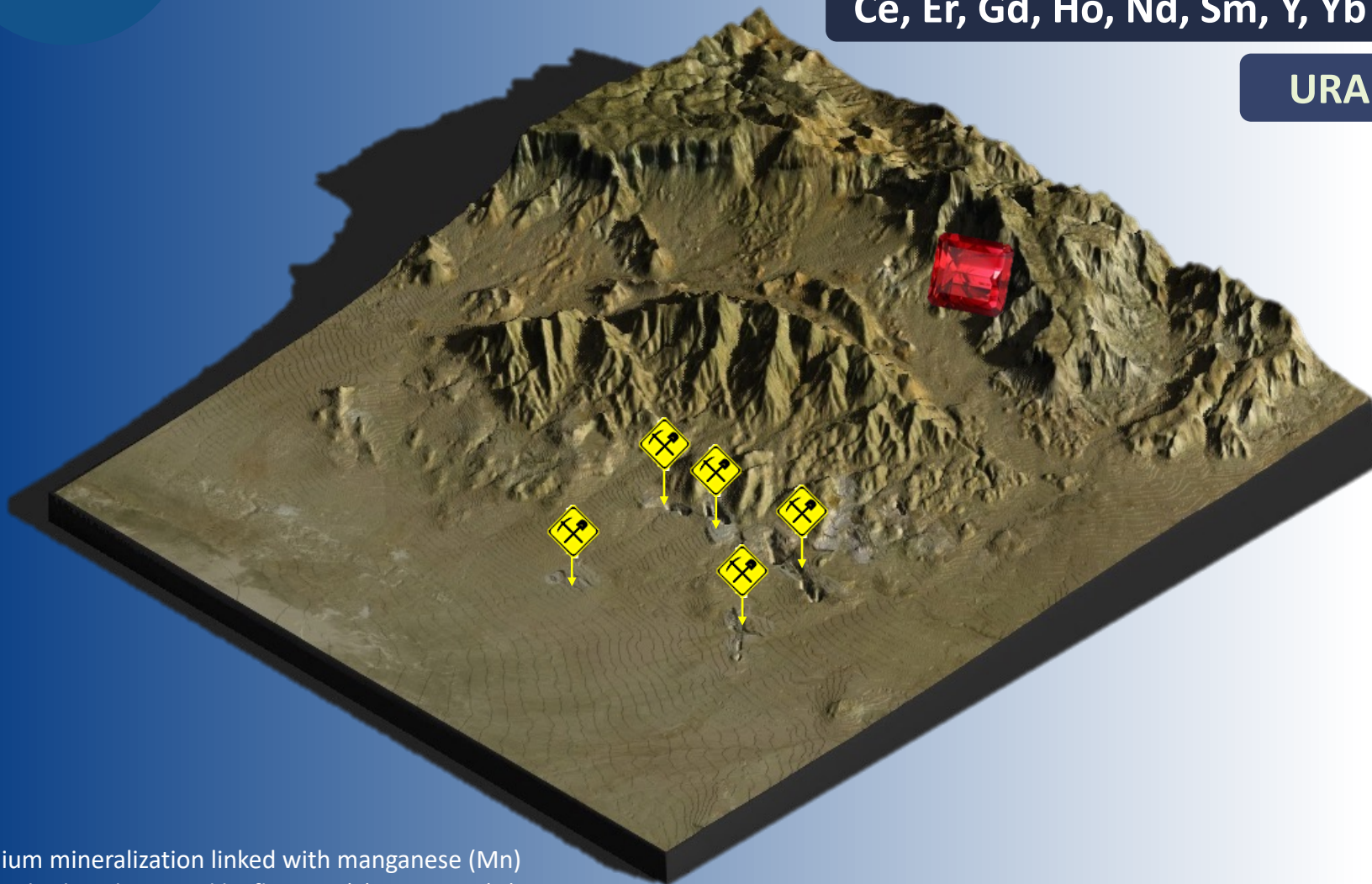
Ce, Er, Gd, Ho, Nd, Sm, Y, Yb

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.

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



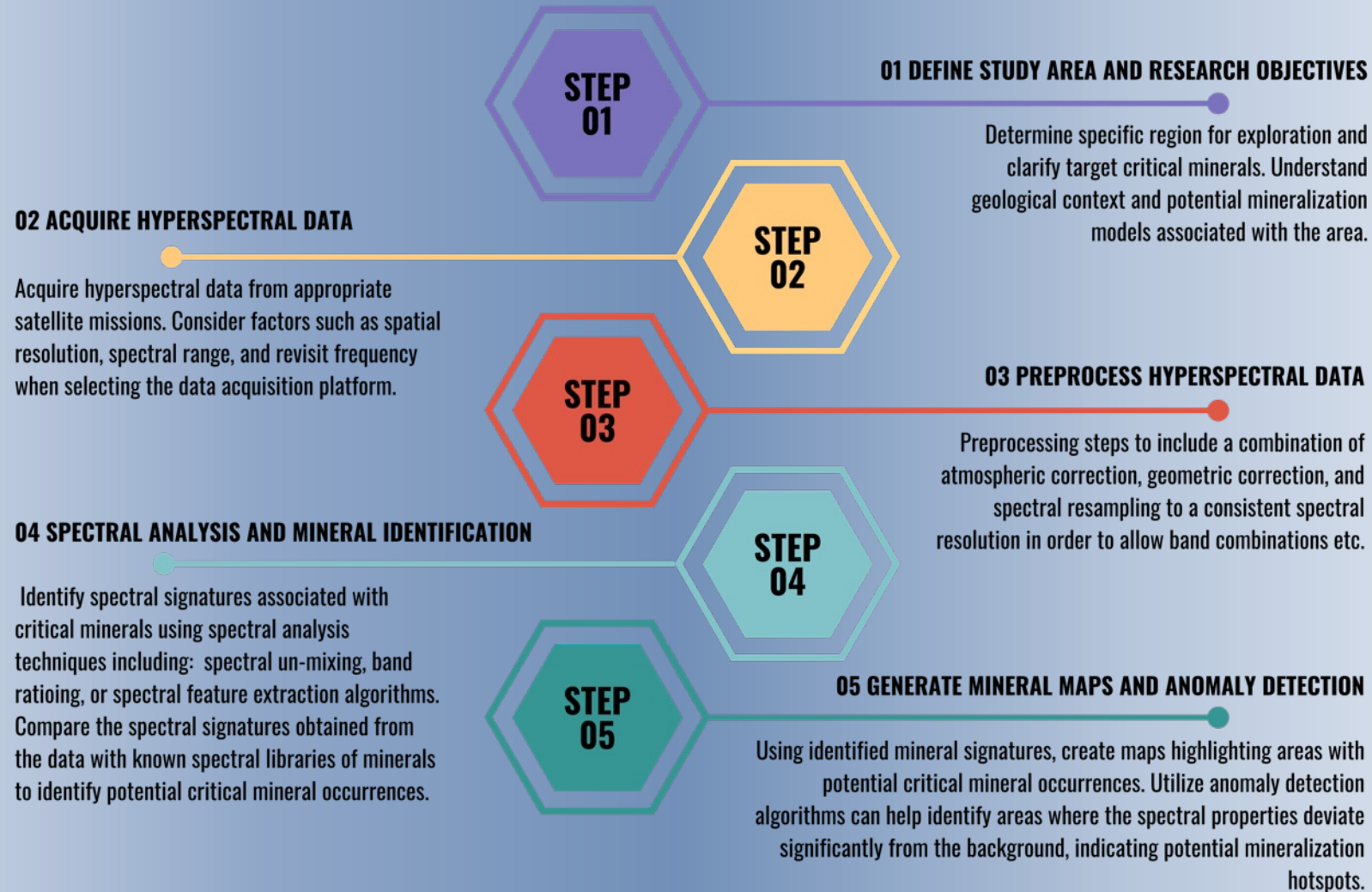
Li Lithium ★
Co Cobalt
Sb Antimony
(C) Graphite

RESEARCH



He Helium
Rb Rubidium
Ce Cesium ★
Bi Bismuth

METHODOLOGY



METHODOLOGY

STEP 01

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.

1

STUDY AREA

Determine areas of intersecting mineralization with historic/active mining areas



2

SATELLITES

Assessment of satellite data combinations useful for identifying mineralization patterns



3

CRITICAL MINERALS

Evaluation and identification of critical mineral mineralization



4

TAILINGS

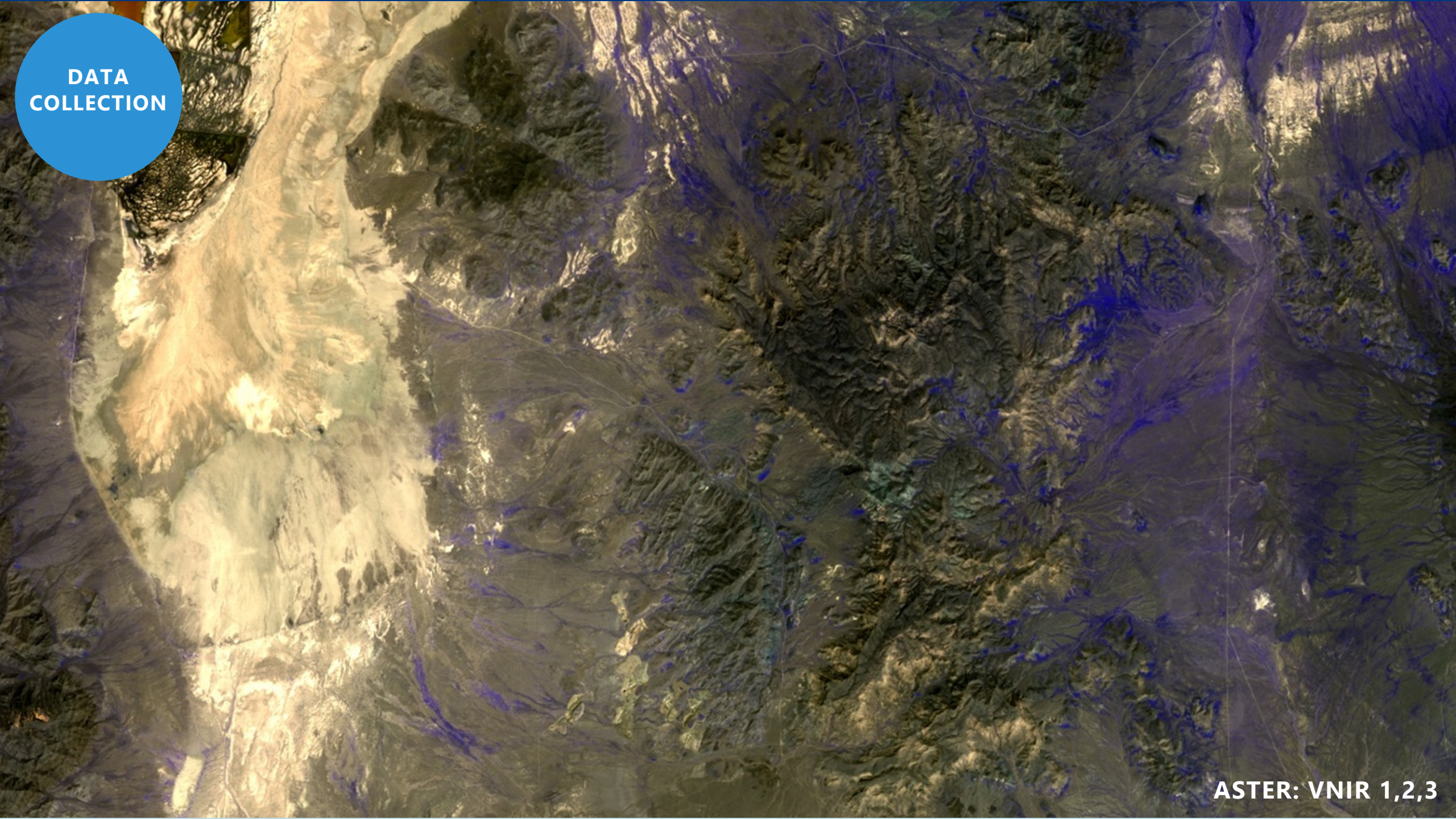
Assessment of tailings types and association to critical minerals



DATA
COLLECTION

WHY SPOR MOUNTAIN?

HYPERSPECTRAL IMAGING ANALYSIS

A satellite image showing a rugged, mountainous landscape. The terrain is characterized by dark, forested slopes and lighter, rocky or snow-covered peaks. A prominent, light-colored, irregularly shaped area is visible on the left side of the image, possibly representing a large body of water or a snowfield. The overall image has a high-contrast, textured appearance typical of satellite imagery. A blue circle is overlaid in the top left corner, containing the text "DATA COLLECTION".

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

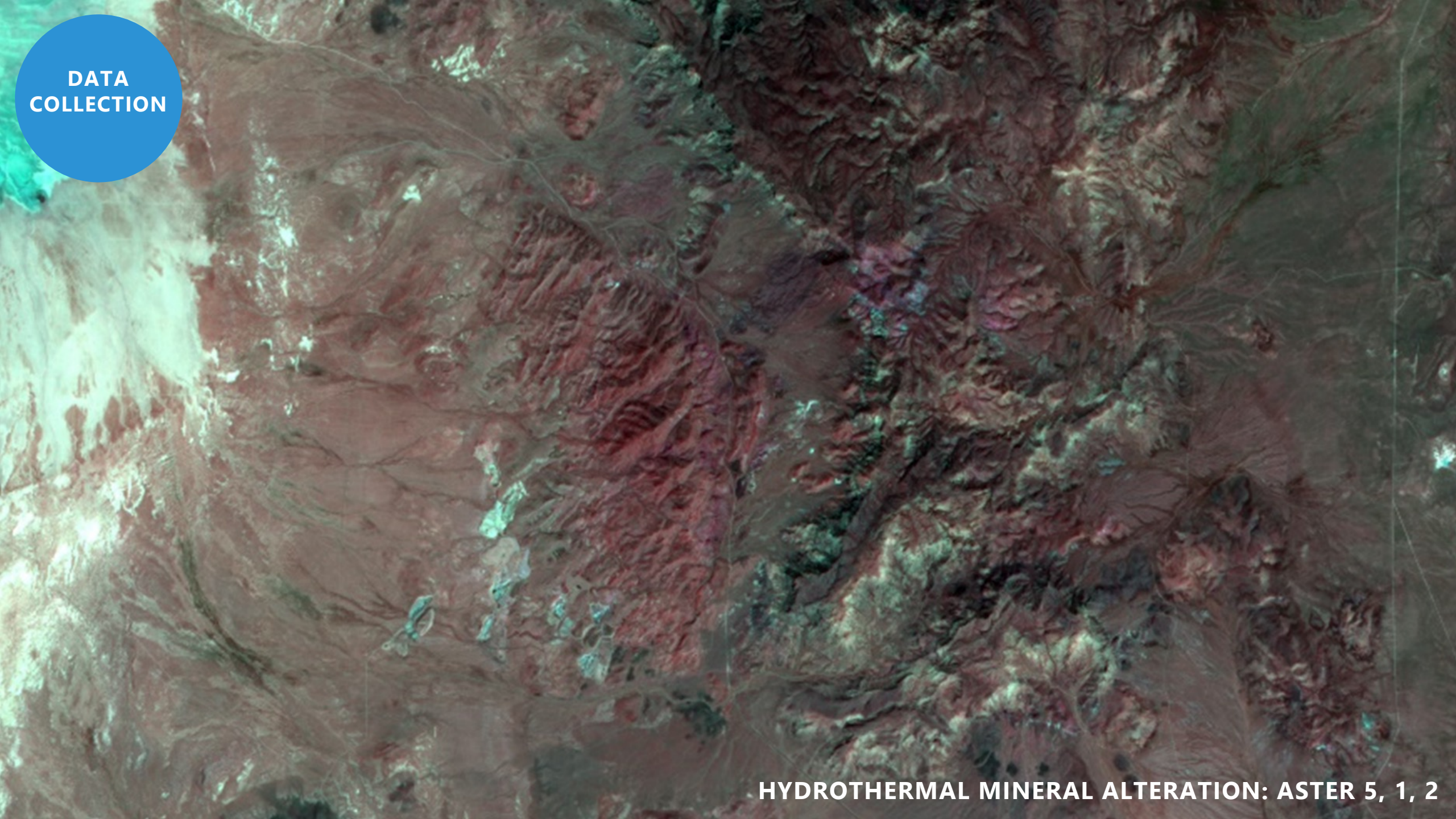
ASTER: VNIR 1,2,3

DATA
COLLECTION

Legend

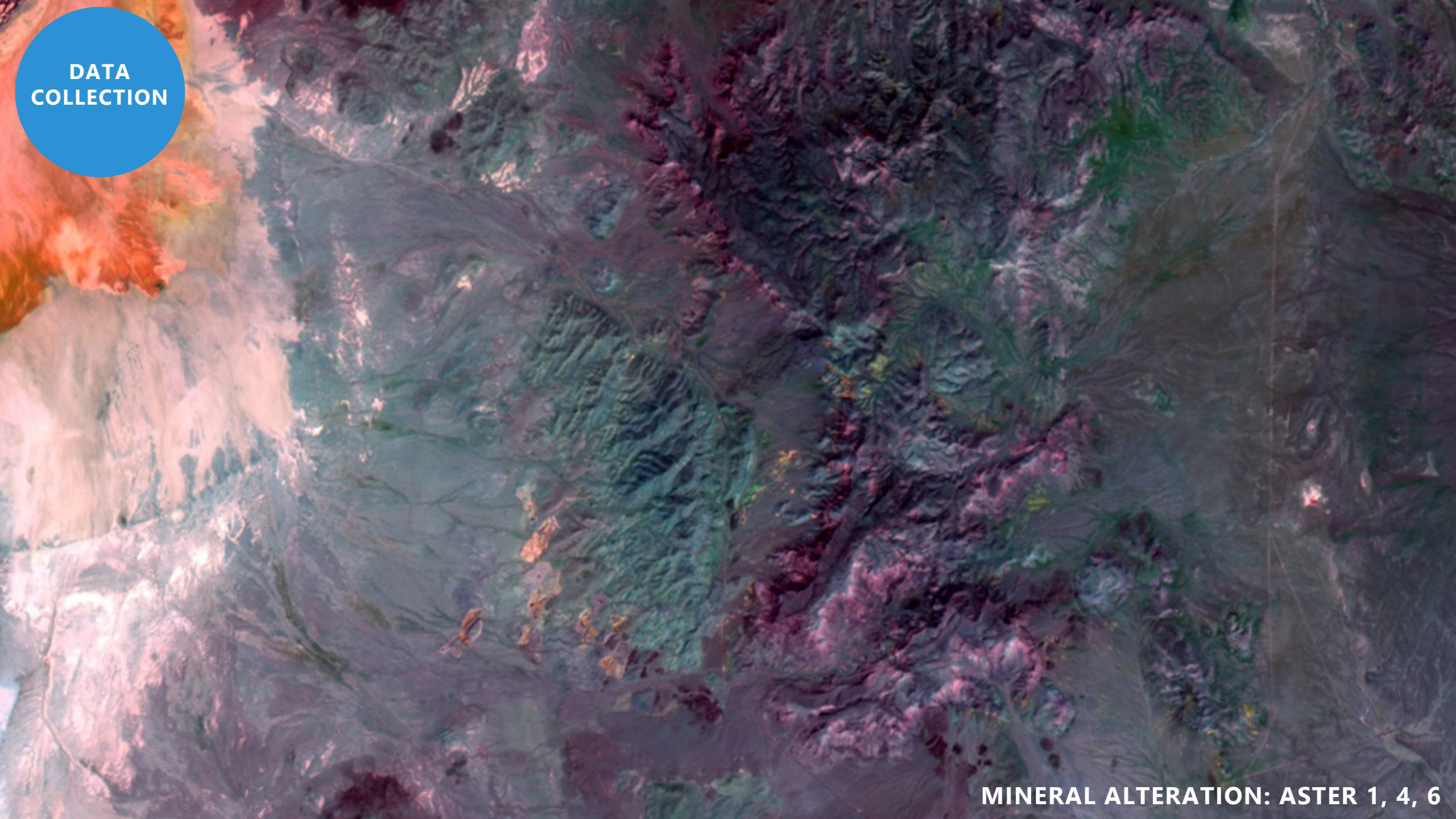
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HYDROTHERMAL MINERAL ALTERATION: ASTER 5, 1, 2

The image is a false-color satellite map derived from ASTER data, showing a complex geological landscape. The terrain is characterized by a variety of colors: deep reds and maroons dominate the central and right portions, indicating specific mineral compositions. These are interspersed with lighter, yellowish-tan areas and darker, almost black regions. The overall texture is highly irregular, with numerous small-scale features and larger, more coherent patches of color, suggesting a history of intense geological activity and fluid flow. The left edge of the image shows a transition to a lighter, more uniform yellowish-green color, possibly representing a different geological unit or a coastal area. The text 'DATA COLLECTION' is overlaid in a blue circle in the top-left corner, and 'HYDROTHERMAL MINERAL ALTERATION: ASTER 5, 1, 2' is displayed in white at the bottom right.

**DATA
COLLECTION**

HYDROTHERMAL MINERAL ALTERATION: ASTER 5, 1, 2



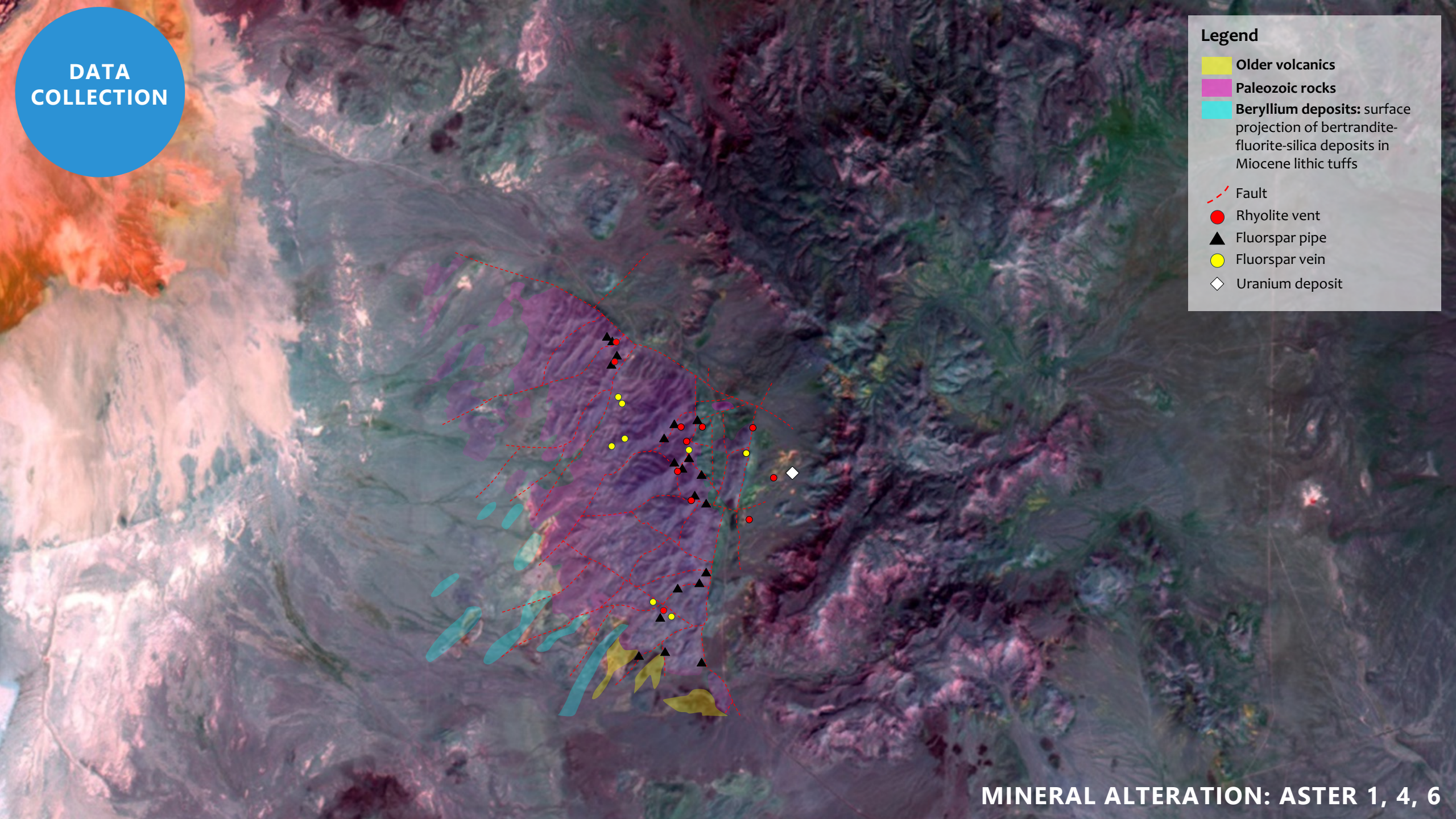
DATA
COLLECTION

MINERAL ALTERATION: ASTER 1, 4, 6

DATA
COLLECTION

Legend

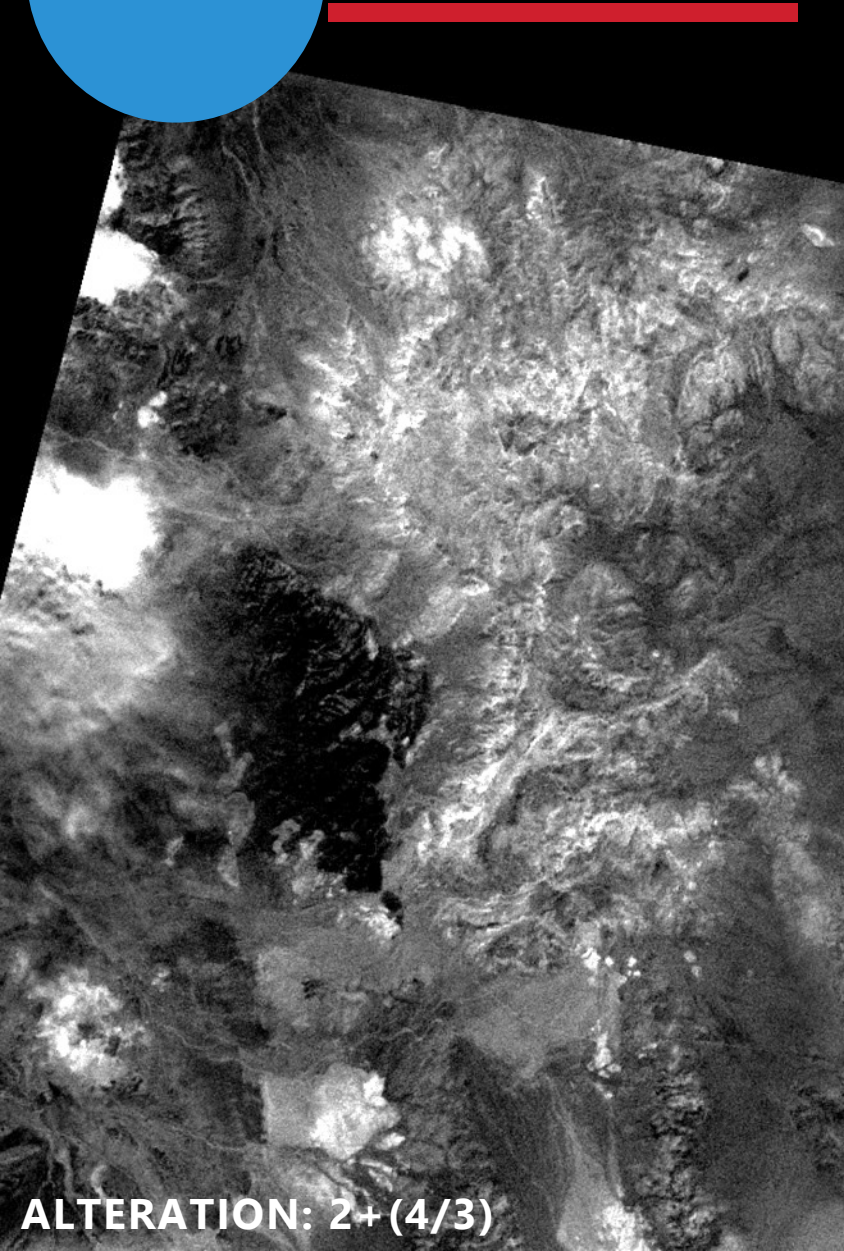
- Older volcanics
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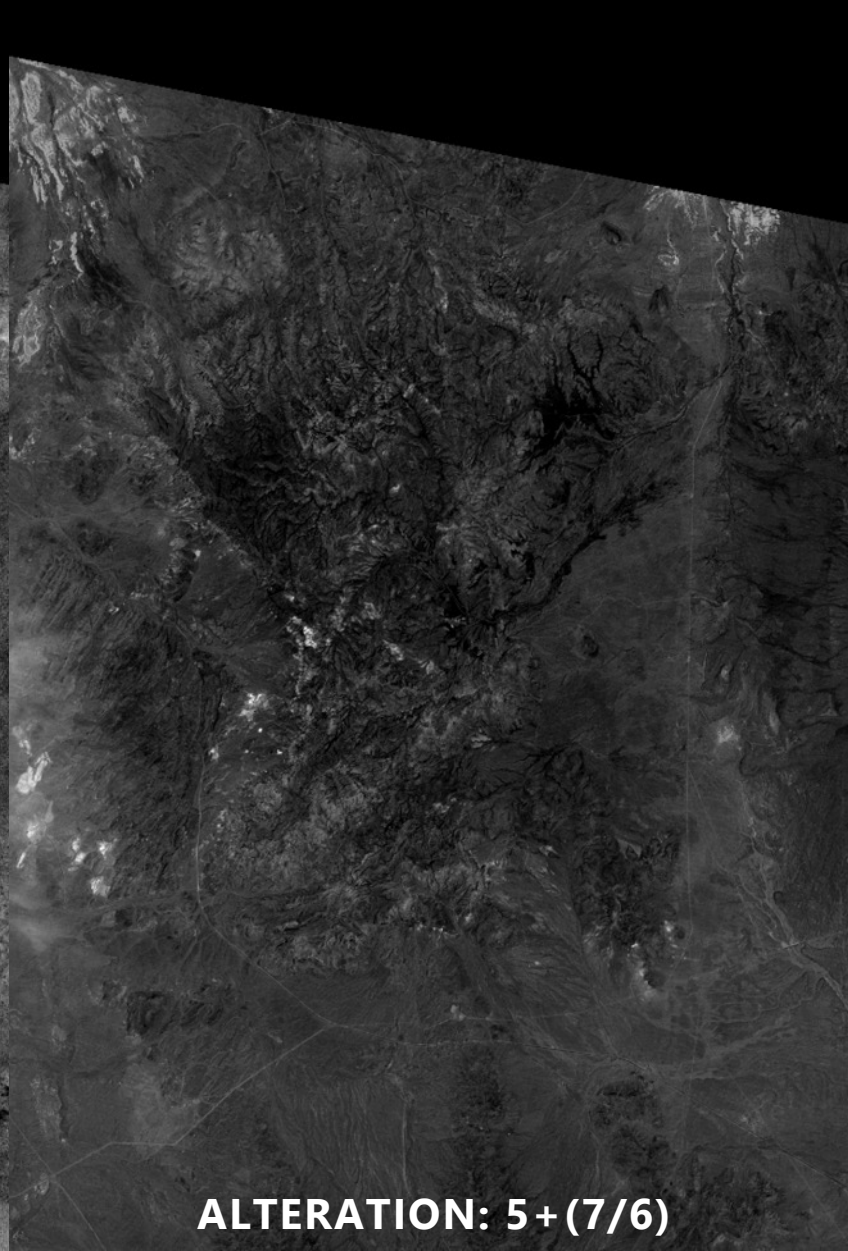
MINERAL ALTERATION: ASTER 1, 4, 6

DATA
COLLECTION

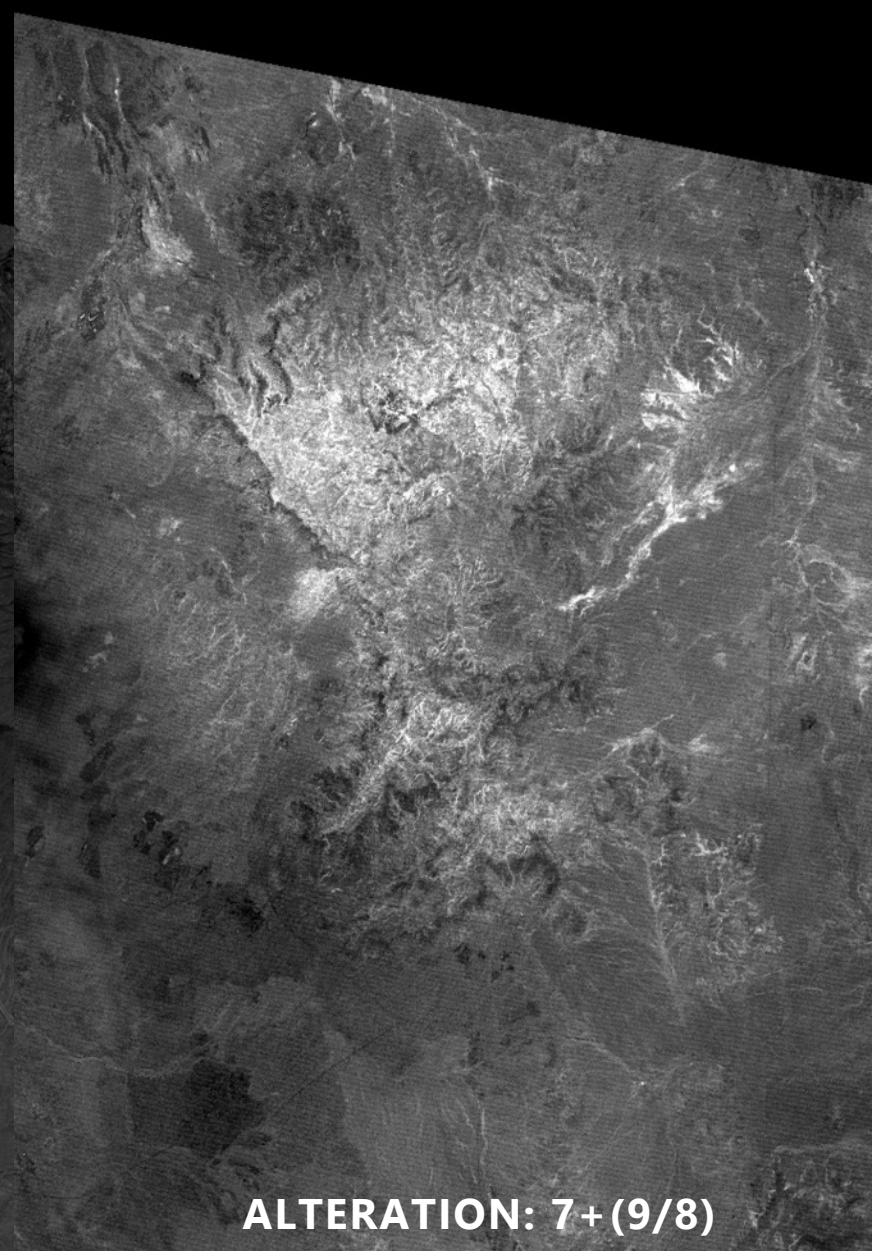
Alteration RGB Aster Imaging



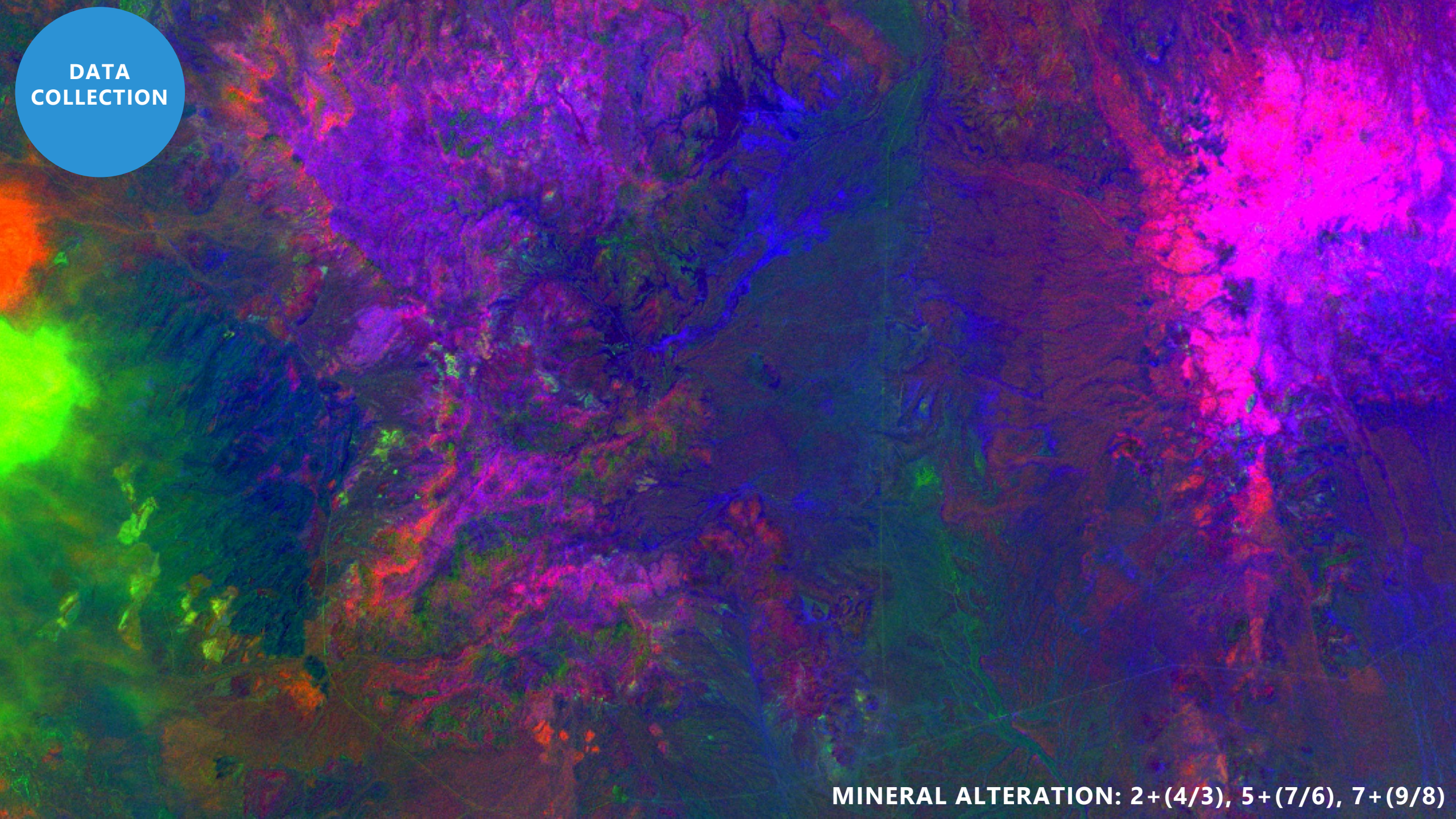
ALTERATION: 2+(4/3)



ALTERATION: 5+(7/6)



ALTERATION: 7+(9/8)

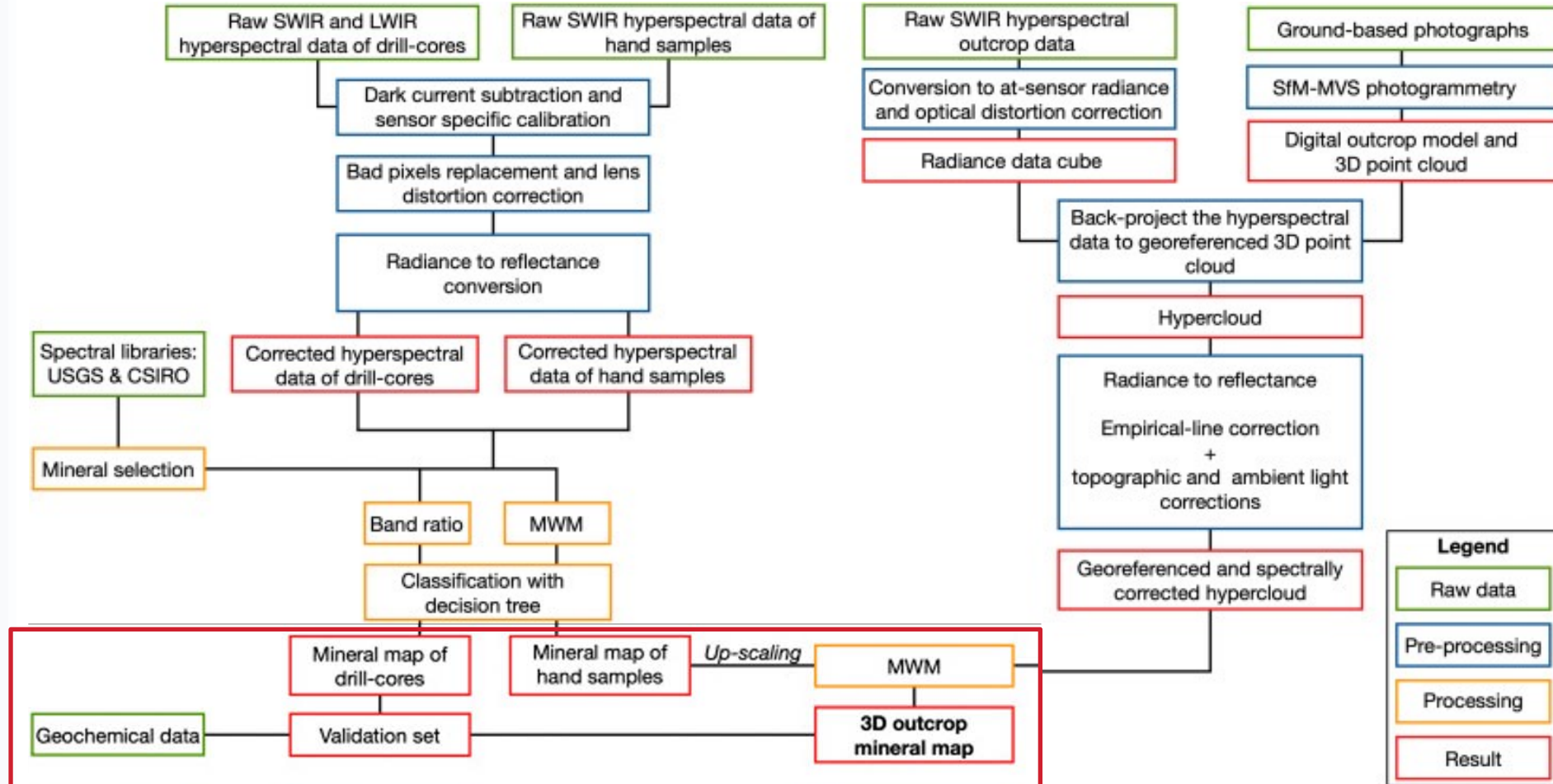


DATA
COLLECTION

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

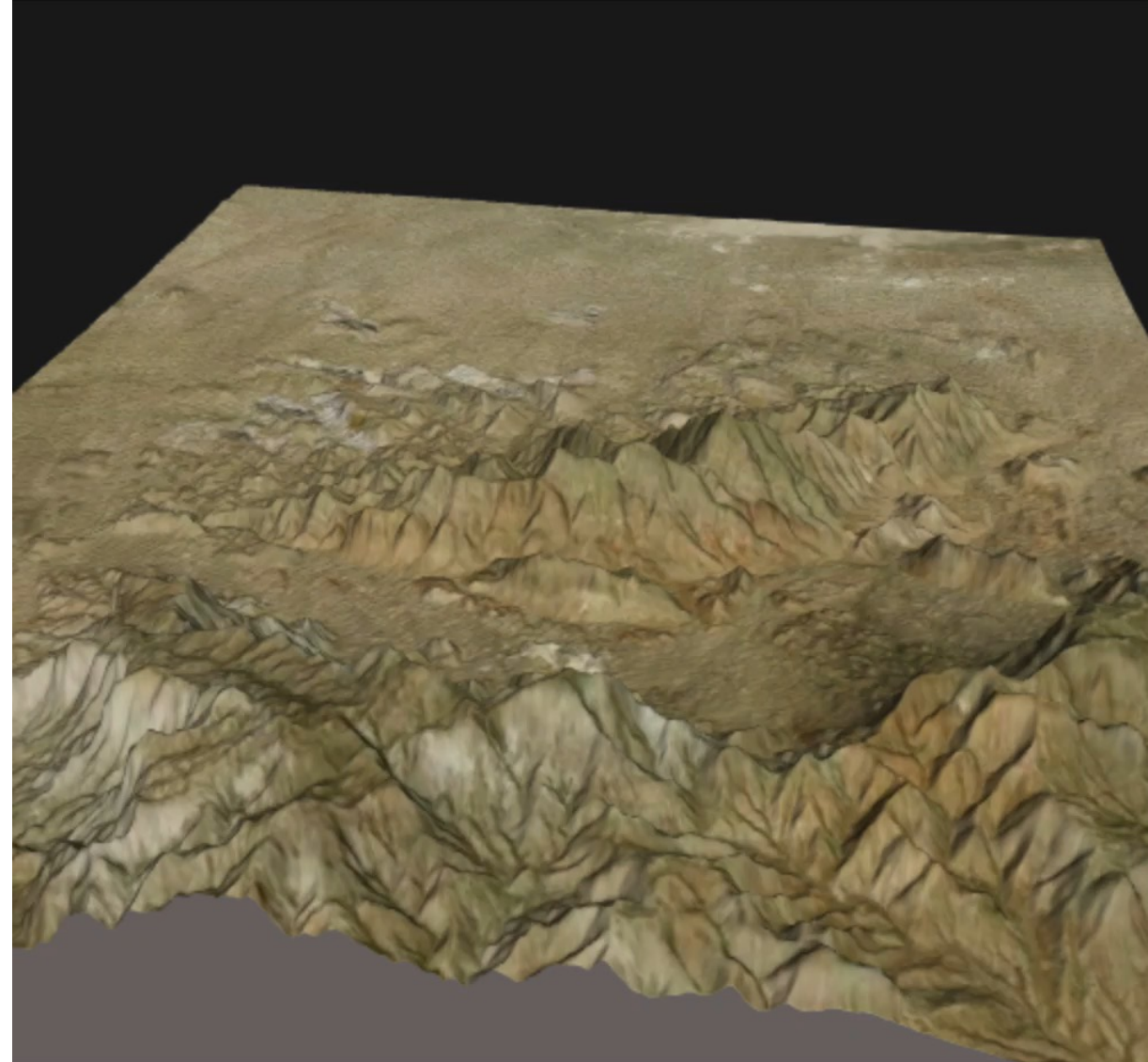
NEXT STEPS

Example workflow from Booyesen et al. 2022



NEXT STEPS

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



1972



2023