Silver Peak Project – Nevada, USA

Mapping alteration minerals using ASTER imagery principal component analysis and band ratios

Advanced **S**paceborne **T**hermal **E**mission and **R**eflection Radiometer (ASTER) is an imaging instrument flying on the Terra satellite, launched in late 1999. ASTER is a cooperative project between NASA, Japan's Ministry of Economy, Trade and Industry and Japan's Earth Remote Sensing Data Analysis Center. The instrument has 3 subsystems that capture readings from different portions of the electromagnetic spectrum at different resolutions. The three subsystems are referred to as VNIR (Visible and Near Infrared), SWIR (Shortwave Infrared) and TIR (Thermal Infrared). Reflectance values in the SWIR range are particularly useful in differentiating rock and soil mineralogy related to alteration zones.

An ASTER image contains 14 bands of information, 4 bands in the VNIR with 15 metre resolution, 6 bands in the SWIR with 30 metre resolution and 5 bands in the TIR with 90 metre resolution.

Module	**VNIR**	**SWIR**	**TIR**
Spectral Bandwidth (μm) [Centre λ (μm)]	Band 1 0.52 – 0.60 [0.556]	Band 4 1.600 – 1.700 [1.656]	Band 10 8.125 – 8.475 [8.291]
	Band 2 0.63 – 0.69 [0.661]	Band 5 2.145 – 2.185 [2.167]	Band 11 8.475 – 8.825 [8.634]
	Band 3N 0.78 – 0.86 [0.807]	Band 6 2.185 – 2.225 [2.209]	Band 12 8.925 – 9.275 [9.075]
	Band 3B 0.78 – 0.86 [0.804] (Backward looking)	Band 7 2.235 – 2.285 [2.262]	Band 13 10.25 – 10.95 [10.657]
		Band 8 2.295 – 2.395 [2.336]	Band 14 10.95 – 11.65 [11.318]
		Band 9 2.360 – 2.430 [2.400]	
Spatial Resolution (m)	15	30	90

Image Pre-Processing

The ASTER imagery been orthorectified, atmospherically and crosstalk corrected before being processed.

Atmospheric corrections were performed on the VNIR (Visible and Near Infrared) and SWIR (Short Wave Infrared) bands in all the images using the FLAASH add on for ENVI (RSI, 2007). This program performs a radiance to relative reflectance correction of the image values by removing the effect of water vapour and other gasses in the atmosphere using the MOTRAN4 technology. Atmospheric correction enhances the digital information from simple DN (uncalibrated instrument readings) values to relative reflectance values that more accurately portray the true reflectance spectra of a ground sample area.

Crosstalk is an effect in ASTER imagery caused by signal leakage from band 4 into adjacent bands 5 and 9. This issue was corrected using software from Japan's Earth Remote Sensing Data Applications Centre (ERSDAC).

Masking

Algorithms to mask vegetation, clouds and water were also applied.

Mineral mapping products

Mineral abundance images of Silver Peak were produced from ASTER bands using PCA (kaolinite, alunite and illite) and band ratios (ferric iron), each one showing areas most likely to contain the alteration minerals. These abundance images are shown in figure 2 to 7, with bright DN values indicating high abundances.

A red, green, blue (RGB) colour composite of abundance images for kaolinite, illite and alunite is presented in figure 5, draped over ASTER band 3.

Mineral endmember identification using PCA and band ratios of ASTER bands

Principal components analysis is a powerful statistical technique that can be used for suppressing irradiance effects that dominate all bands, therefore enhancing spectral reflectance features of geological materials. PCA can be applied to remote sensing images, with the purpose of extracting specific spectral responses, as in the case of alteration minerals. PCA was applied to subsets of four ASTER bands. The subsets were selected according to the position of characteristic spectral features of key alteration mineral endmembers in the VNIR and SWIR portions of the spectrum.

After applying PCA, the eigenvector matrix used to calculate PCA for each subset was examined, to identify which PC contained the target (mineral) information.

The band rationing is another method for target material recognition. This procedure involves the division of two bands, where the band with high reflectance features of the given material is assigned as numerator, while the other band with high absorption features for the same material is assigned as denominator.

There is an important thing to note when using ASTER imagery for regional mineralogical mapping. **Bands, band ratios and principal component analysis do not indicate the occurrence of a mineral with absolute certainty or with any idea of quantity, so ground truthing is essential.**

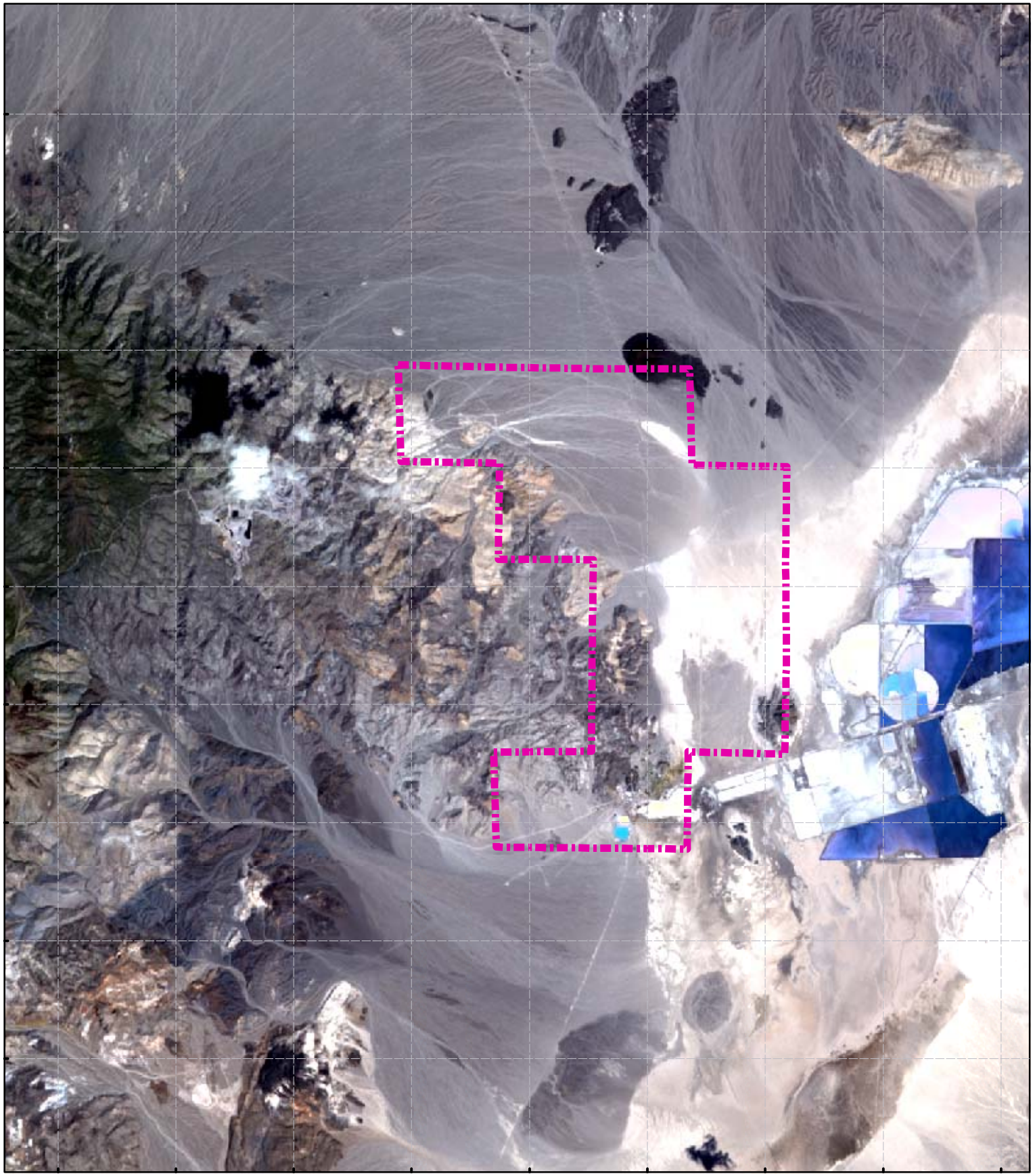

Fig. 1: Aster Natural Color Composite

Legend

Lease Area

N

0 3,000

Meters

Projection: UTM NAD 83, Zone 11(m)

SIERRA Geothermal Power Corp.

Silver Peak Project

Nevada, U.S.A.

Date: November 2007

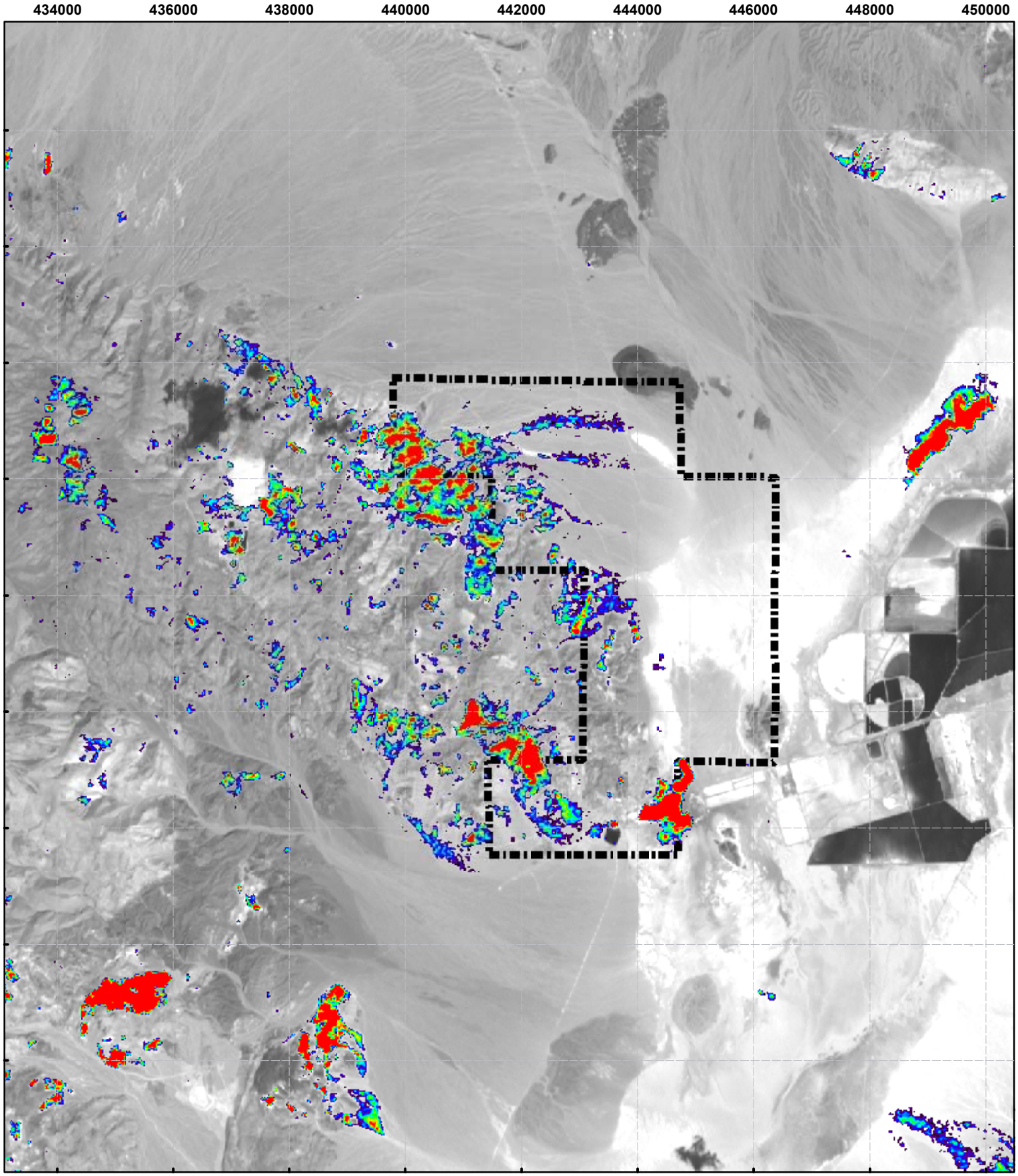

Fig. 2: Kaolinite - Vnir band 3 Aster

High Abundance

Low Abundance

N

0 3,000

Meters

Projection: UTM NAD 83, Zone 11(m)

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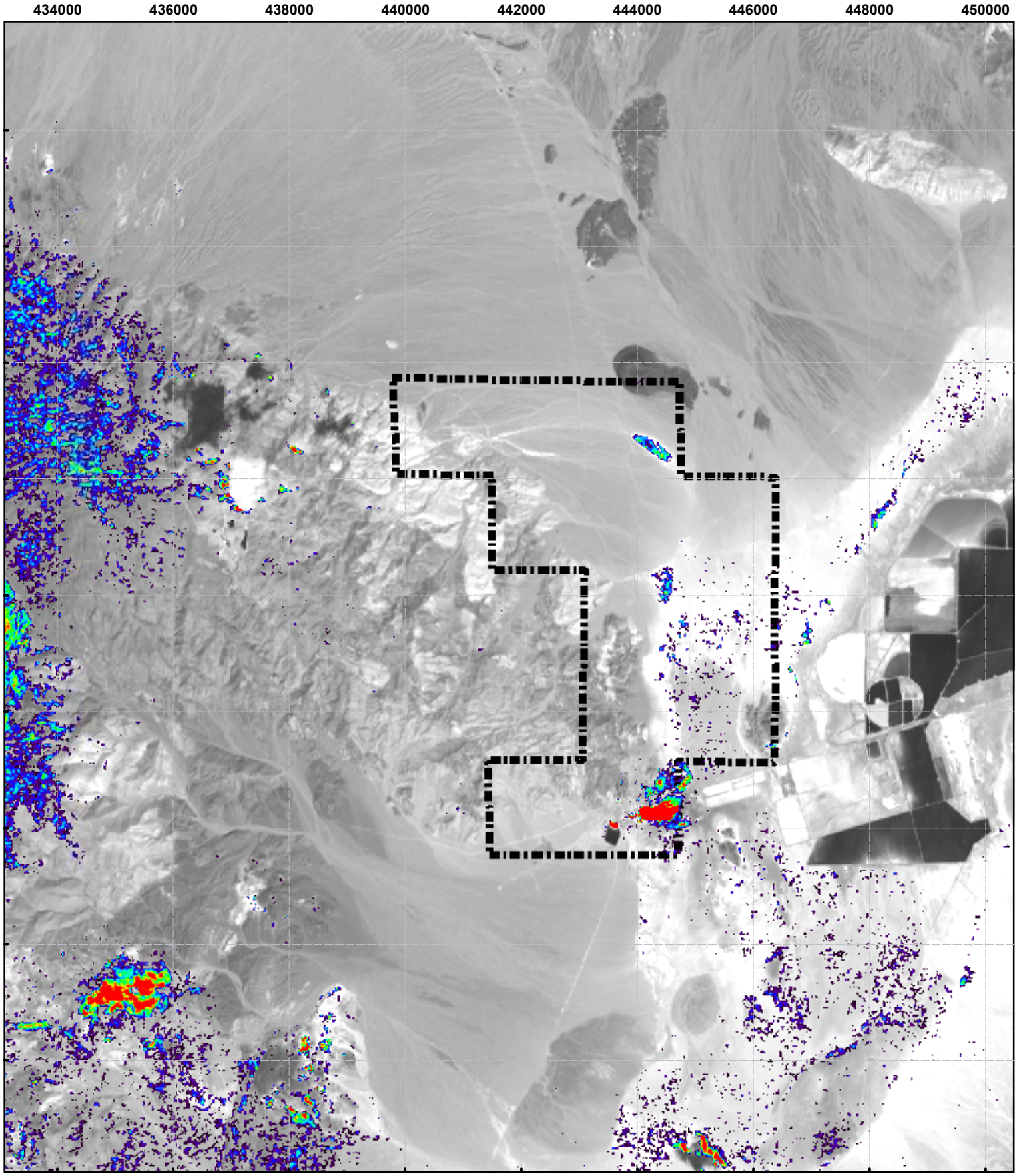

Fig. 3: Alunite - Vnir band 3 Aster

High Abundance

Low Abundance

N

0 3,000

Meters

Projection: UTM NAD 83, Zone 11(m)

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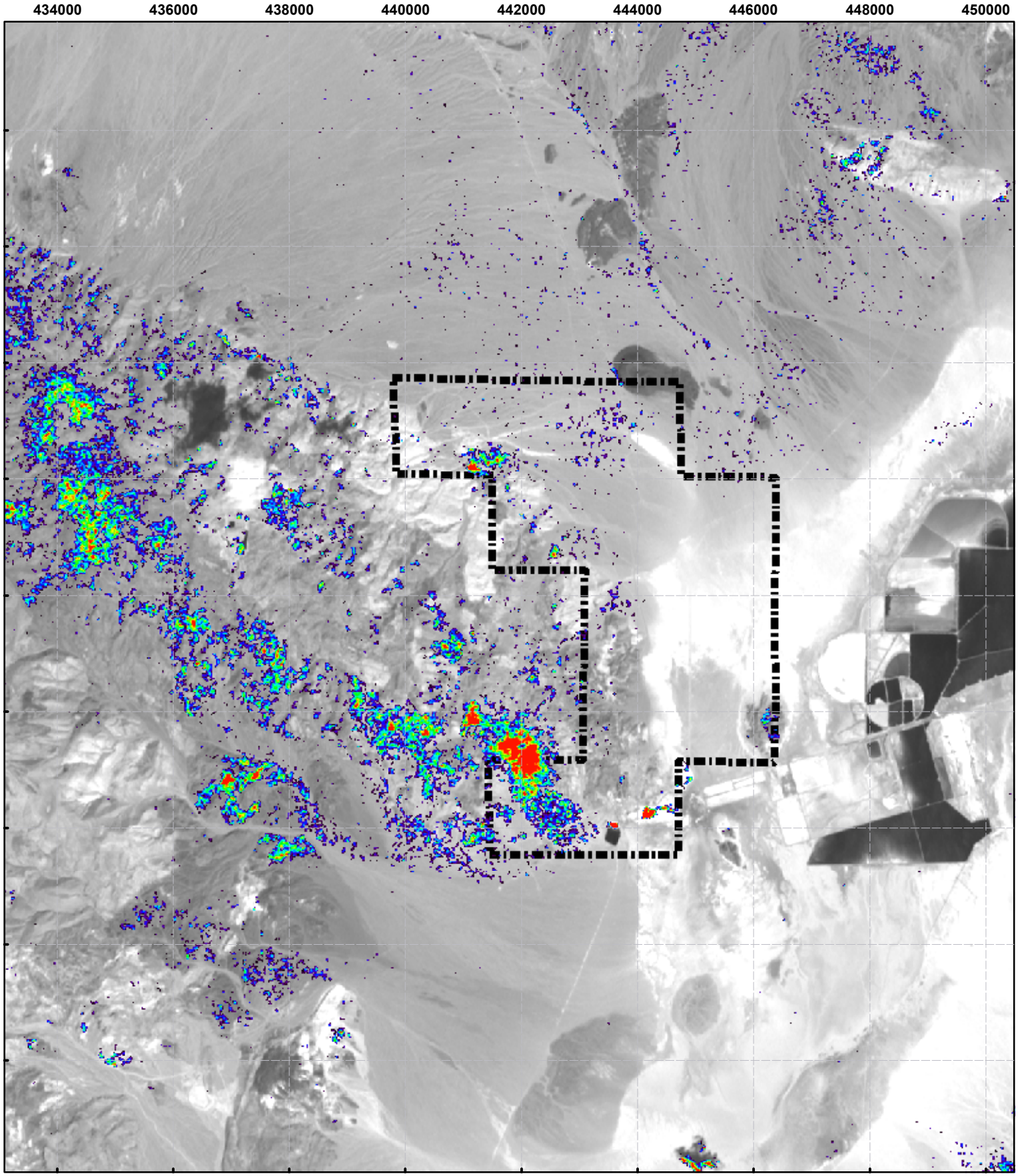

Fig. 4: Illite - Vnir band 3 Aster

High Abundance

Low Abundance

N

0 3,000

Meters

Projection: UTM NAD 83, Zone 11(m)

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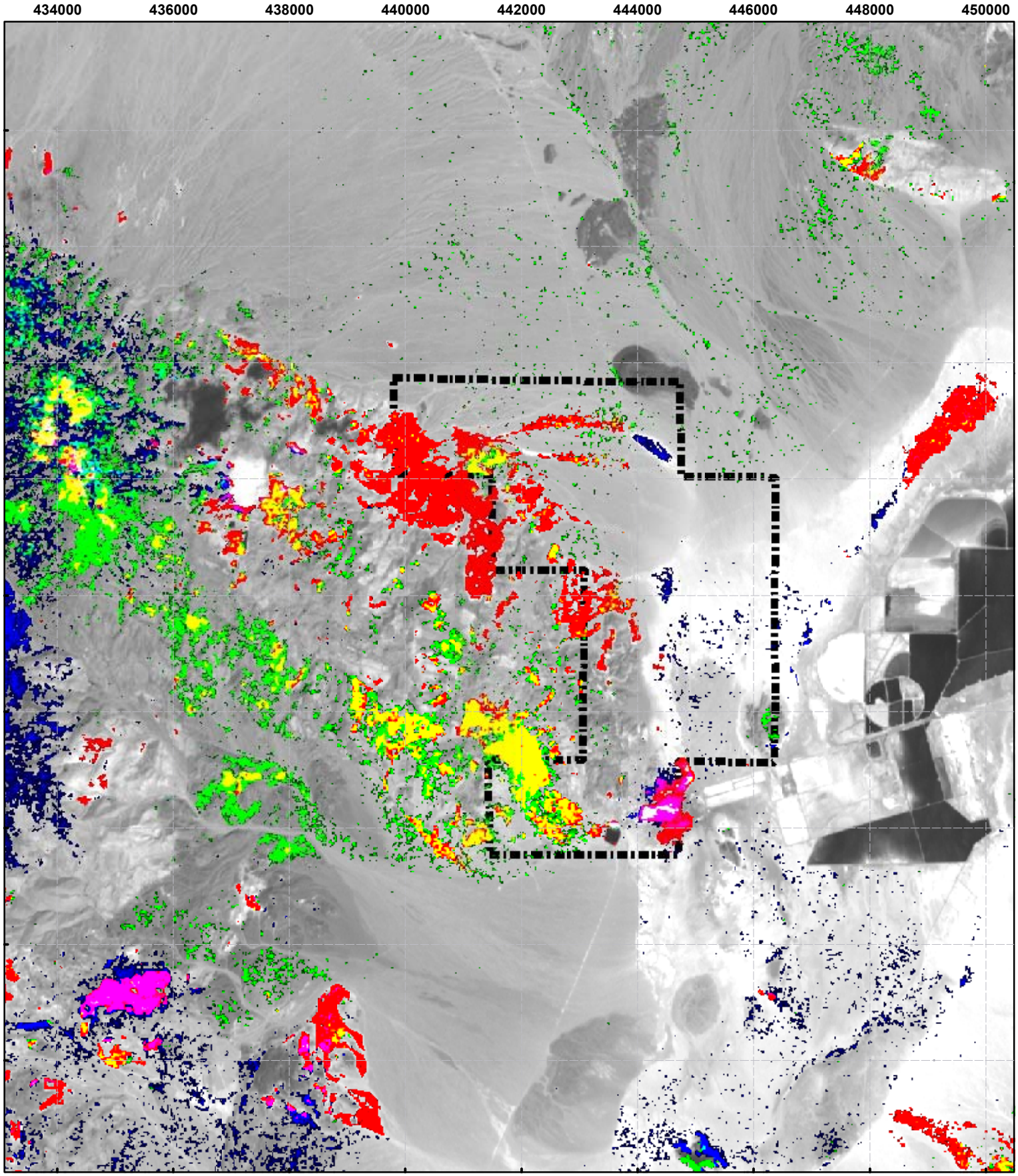
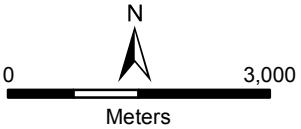


Fig. 5: Colour composite of abundance images for kaolinite, illite and alunite in RGB draped over Aster Vnir band 3



Projection: UTM NAD 83, Zone 11(m)

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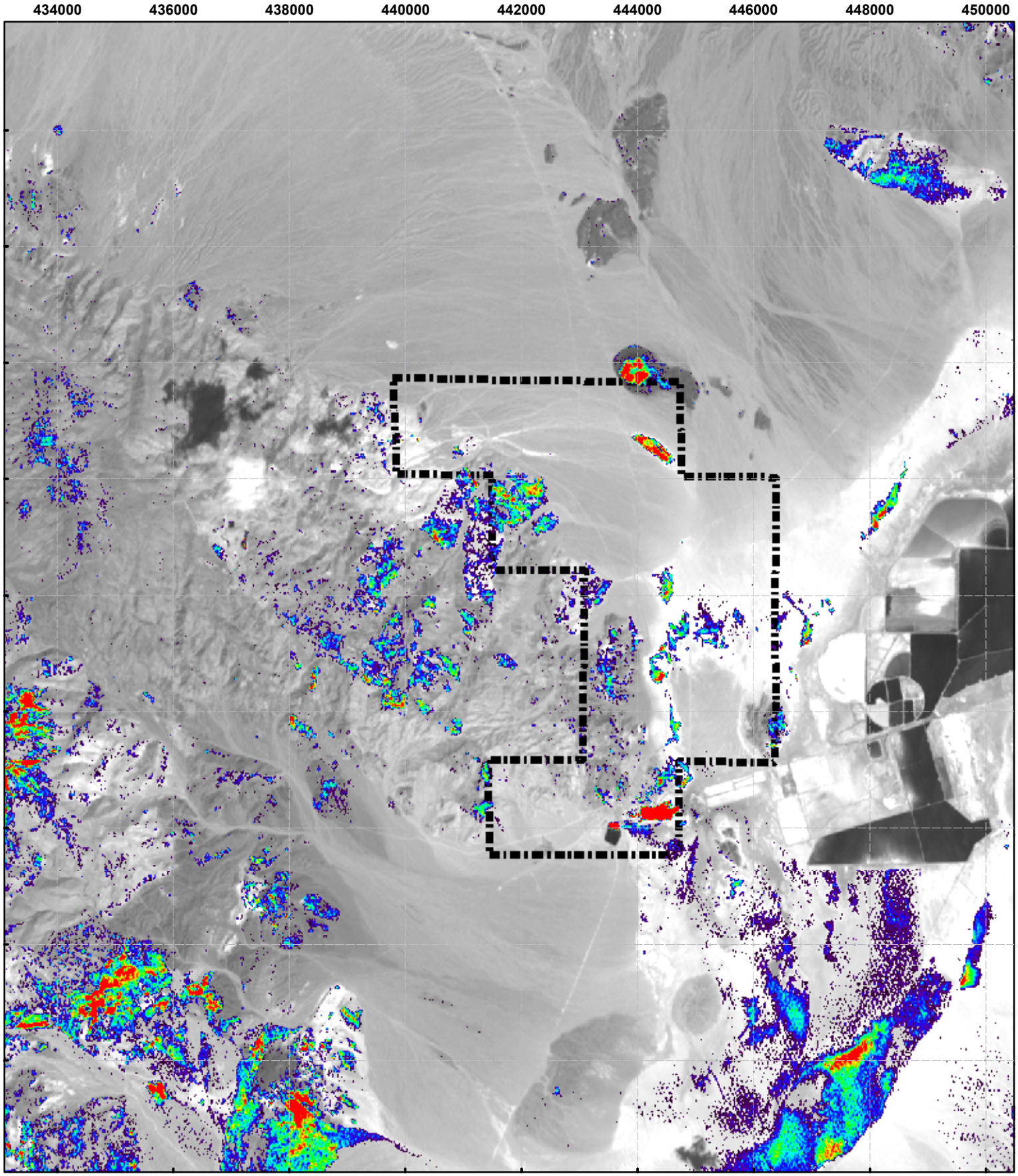

Fig. 6: Ferric Iron - Vnir band 3 Aster

High Abundance

Low Abundance

N

0 3,000

Meters

Projection: UTM NAD 83, Zone 11(m)

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