# Mineral Marker Maps

## Introduction

Our proposal includes in subtask 2.1 the identification of Mineral Markers and mapping using several algorithms. We have changed some of the algorithms proposed originally, and settled on the algorithms in Table 1. The descriptions are from (Exelis Visual Information Solutions, 2010).

Table - List of algorithms used. They are available through the ENVI software from Exelis.

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| Spectral Angle Mapper (SAM) | a physically-based spectral classification that uses an n-D angle to match pixels to reference spectra. The algorithm determines the spectral similarity between two spectra by calculating the angle between the spectra and treating them as vectors in a space with dimensionality equal to the number of bands |
| Matched Filtering (MF) | finds the abundances of user-defined endmembers using a partial unmixing. This technique maximizes the response of the known endmember and suppresses the response of the composite unknown background, thus matching the known signature |
| Mixture Tuned Matched Filtering (MTMF) | performs Matched Filtering (MF) and adds an infeasibility image to the results. The infeasibility image is used to reduce the number of false positives that are sometimes found when using MF. Pixels with a high infeasibility are likely to be MF false positives. |
| Adaptive Coherence Estimator (ACE) | The ACE is invariant to relative scaling of input spectra and has a Constant False Alarm Rate (CFAR) with respect to such scaling. |

In order to validate our approach, we used the methodology in (Kratt, 2006), which consists of four steps:

1. Collect hyperspectral data: In our case, instead of using high quality data we used AVIRIS, which has a resolution of 14.3 m by 14.3 m. This impacts the quality and resolution of our results and may lead to missing patches of marker minerals
2. Select pixels representative of the region: We used Sequential Maximum Angle Convex Cone (SMACC) to acquire representative endmember pixels in the region (L3Harris Geospatial, 2020). This algorithm is a rapid way to identify representative pixels, with the drawback of being less precise than supervised methods.
3. Compare pixels in relevant areas to USGS spectra library and identify minerals: Based on our literature review, we identified several minerals that indicate presence of geothermal regions. When comparing our endmembers to the library we were able to match several of them. This list includes Kaolinite, Chalcedony, Montmorillonite, Saponite, Vermiculite, and others
4. Create maps indicating presence of the minerals by applying a mapping algorithm: the paper uses MTMF; we decided to also use SAM, MF and ACE

The paper (Kratt, 2006), in figure 10, shows regions with sinters from opal (Opal-A, Opal-C, chalcedony and others). We sampled a representative pixel from this area and mapped using MTMF.



Figure - Comparison between the results of applying MTMF to Opal-like pixels in A) Kratt (2006) and B) Our analysis. The red square regions correspond to the same geographical area in both images.

As can be observed from Figure 1, there is a good match between our results and the Kratt paper.

## Maps

### Spectral Angle Mapper (SAM)

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| **Chalcedony** |

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| **Kaolinite** |

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| **Hematite** |

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| **Gypsum** |

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| **Saponite** |

### Matched Filtering

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| **Chalcedony** |

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| **Kaolinite** |

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| **Hematite** |

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| **Gypsum** |

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| **Saponite** |

### Mixture Tuned Matched Filtering

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| **Chalcedony** |

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| **Kaolinite** |

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| **Hematite** |

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| **Gypsum** |

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| **Saponite** |

### Adaptive Coherence Estimator (ACE)

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| **Chalcedony** |

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| **Kaolinite** |

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| **Hematite** |

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| **Gypsum** |

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| **Saponite** |

# References

Exelis Visual Information Solutions. (2010). *ENVI Manual.* Boulder, Colorado: Exelis Visual Information Solutions.

Kratt, C. C. (2006). *Geothermal exploration with Hymap hyperspectral data at Brady–Desert Peak, Nevada.* (Vol. 104(3)). Remote Sensing of Environment.

L3Harris Geospatial. (2020, 1 29). *ENVI Documentation*. Retrieved from L3Harris Geospatial Solutions: https://www.harrisgeospatial.com/docs/SpectralMappingMethods.html