Experiments with Cuprite Image

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The scene used here is the well known Airborne Visible Infrared Imaging Spectrometer (AVIRIS) Cuprite data set, which has been widely used to validate the performance of endmember extraction algorithms. The portion used in experiments corresponds to a 250× 191 pixel subset of the sector labeled f970619t01p02r02 in the online data[1]. The scene comprises 224 spectral bands between 0.4 and 2.5 μm. Prior to the analysis, bands 1–2, 105–115, 150–170, and 223–224 were removed due to water absorption and low SNR in those bands, leaving a total of 188 spectral bands. The Cuprite site is well understood mineralogically and has several exposed minerals of interest, all included in the USGS library considered in experiments, denoted splib06[2] and released in September 2007.

To substantiate the quality of the endmembers derived by NMF-QMV, we compare estimated endmembers with spectral signatures in the library in sense of spectral angle distance (SAD) (in degrees), which is defined as

$$\mathrm{SAD}(\mathbf{A}, \widehat{\mathbf{A}}) \triangleq \frac{180}{p\pi} \sum_{i=1}^{p} \arccos \frac{\hat{\mathbf{a}}_i^T \mathbf{a}_i}{\|\hat{\mathbf{a}}_i\|_2 \|\mathbf{a}_i\|_2}. \tag{1}$$

Considering saving space, we only conduct experiments with NMF-QMV in this work. For a more detailed comparison with other methods, we refer to the work in [1]. Fig. 1 provides a reference of mineral distribution for evaluation. Number of endmembers is considered as $p = 10$ in this work. The estimation of number of endmembers is still an open problem, even though it can be $p = 14$ [2] estimated by HySime [3] or $p = 9$ estimated by VD in this image. Through visual interpretation, we choose $p = 10$, which is also used in [1].

Unmixing results of NMF-QMV with 3 MV term are given in Figs. 2, 3 and 4, respectively. Note that spectral signatures from splib06 library are compared with estimated endmembers in sense of SAD. Matched ones from splib06 library are plotted in blue color as reference ones. On the right hand side of each sub-plot, we show abundance maps of corresponding endmembers. We remark that imaging (or measurement) environments are completely different. Signatures from splib06 are acquired in perfect lab environment, whereas Cuprite image suffers from atmospheric interferers and sensor noise. Results in Figs. 2, 3 and 4 indicate that estimated endmembers and abundances are reasonable and have a good match to library signatures.

References

[1] J. Li, J. M. Bioucas-Dias, A. Plaza, and L. Liu, "Robust collaborative nonnegative matrix factorization for hyperspectral unmixing," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 54, no. 10, pp. 6076–6090, Oct. 2016.

[2] J. Li and J. M. Bioucas-Dias, "Minimum volume simplex analysis: A fast algorithm to unmix hyperspectral data," in *IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, vol. 3, Jul. 2008, pp. III – 250–III – 253.

[3] J. M. Bioucas-Dias and J. M. P. Nascimento, "Hyperspectral subspace identification," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 46, no. 8, pp. 2435–2445, Aug. 2008.

[1] `http://www.lx.it.pt/~bioucas/code.htm`

[2] `http://speclab.cr.usgs.gov/spectral.lib06`

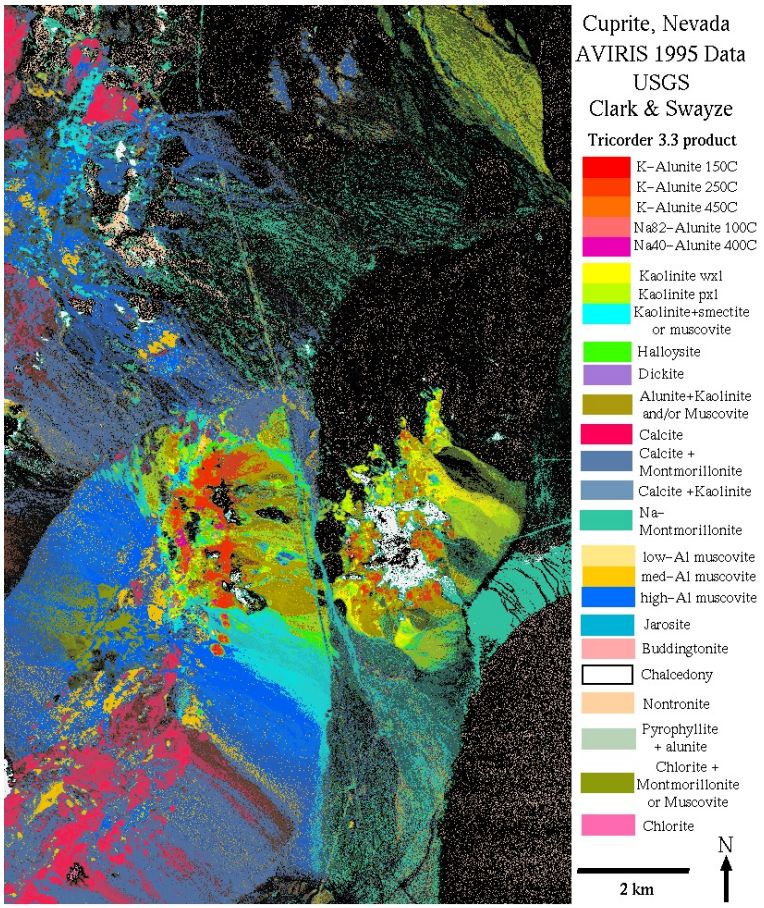

Figure 1. Mineral map of Cuprite mining district provided by USGS in 1995.

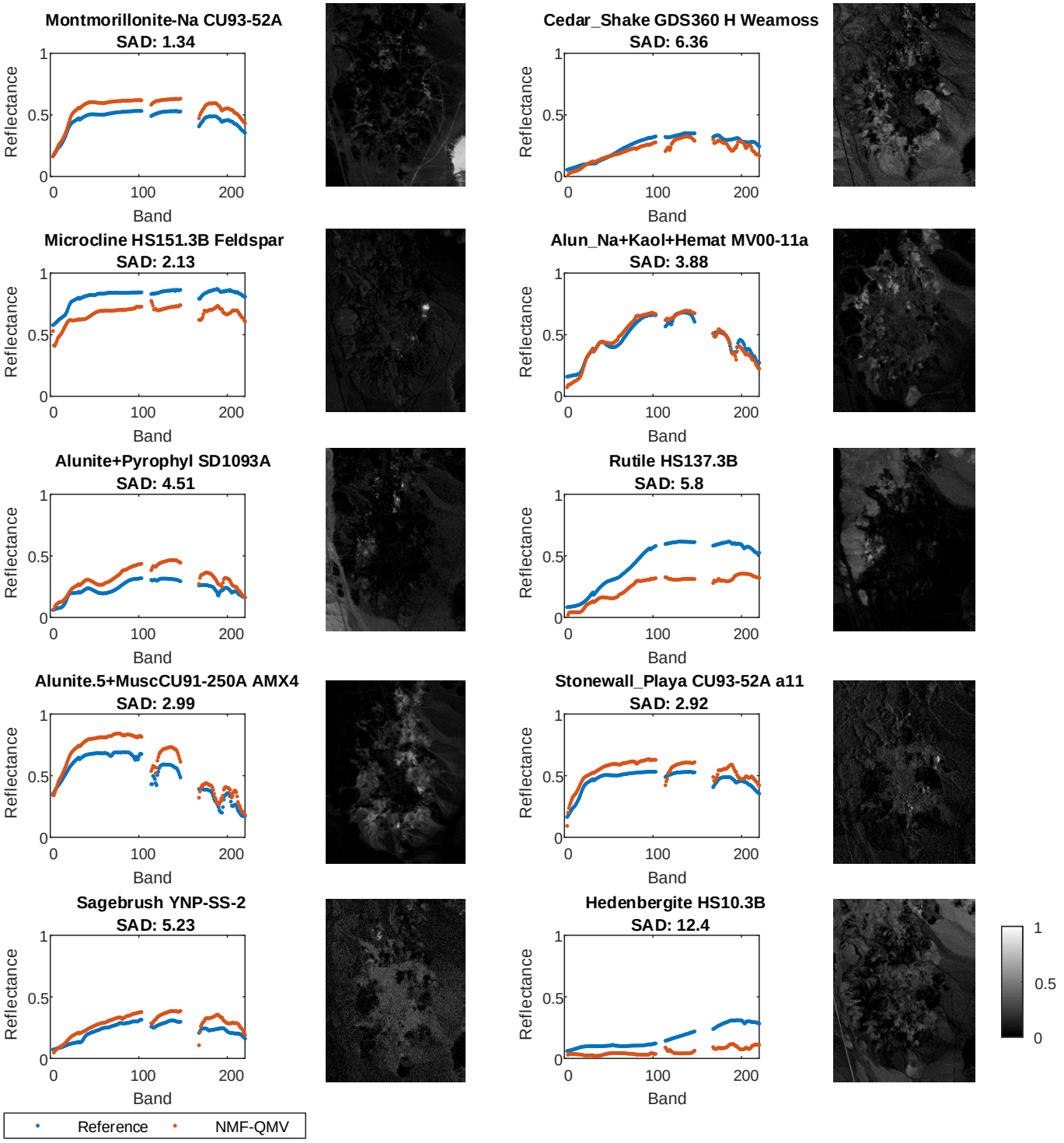

Figure 2. Endmembers and abundance maps estimated by NMF-QMV with 'boundary' MV term.

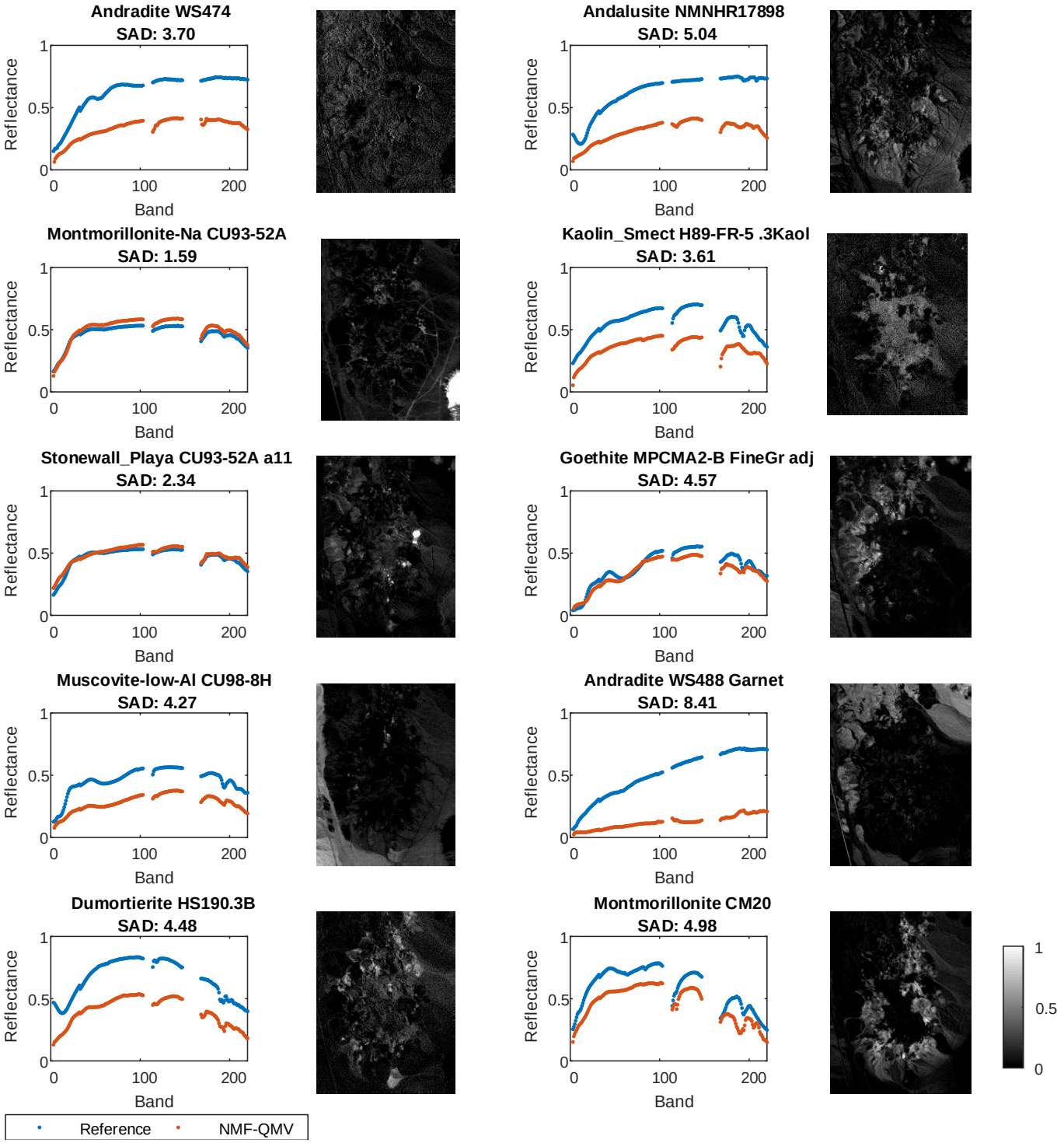

Figure 3. Endmembers and abundance maps estimated by NMF-QMV with 'center' MV term.

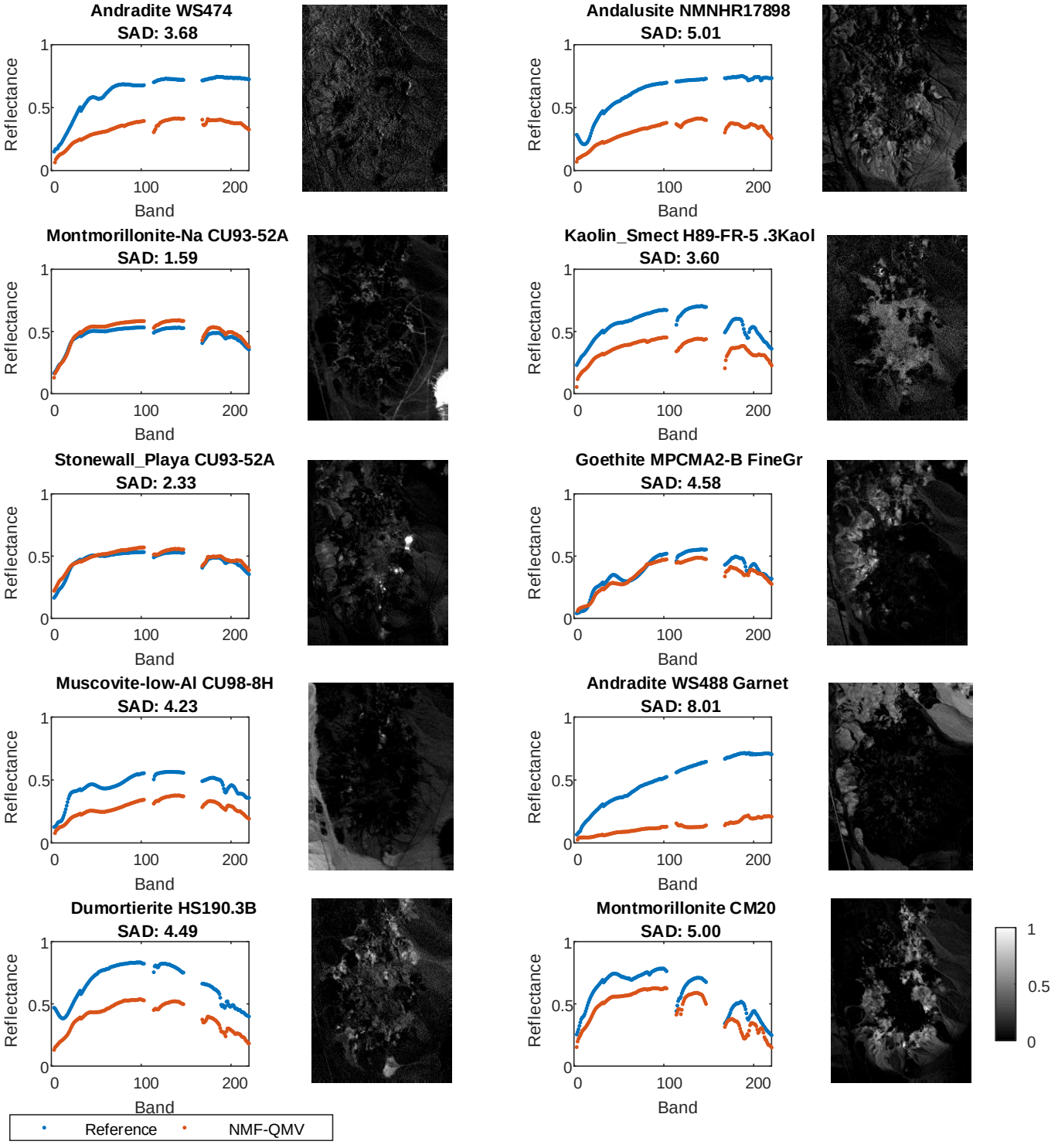

Figure 4. Endmembers and abundance maps estimated by NMF-QMV with 'TV' MV term.