CHARACTERIZATION OF SERPENTINE AND CARBONATE IN MARS 2020 LANDING SITE CANDIDATES USING INTEGRATED DYNAMIC APERTURE TARGET TRANSFORMATION AND SPARSE UNMIXING (IDATTSU) J. D. Tarnas[1], Honglei Lin[2], J. F. Mustard[1], and Xia Zhang[2] B., [1]Brown University, Dept. of Earth, Environmental and Planetary Sciences, Providence RI (jesse_tarnas@brown.edu), [2]Institute of Remote Sensing and Digital Earth, CAS, Beijing, 100101

Introduction: Carbonate (magnesite) is well known to exist in the NE Syrtis and Jezero crater Mars 2020 candidate landing sites [1,2]. Alteration pathways from olivine to carbonate typically include serpentine as an intermediate step, but it has not been detected using typical techniques in the Jezero crater or NE Syrtis landing site ellipses or primary exploration zones. Serpentine and talc have been hypothesized to be present [3,4], but no outcrop of talc or serpentine has been characterized within the landing ellipses. The innovative Factor Analysis Target Transformation (FATT) technique has been applied to TES data [5] and recently to CRISM data [4,6]. A strength of FATT is the ability to detect spectral signatures from minerals sparsely distributed throughout an image or complexly convolved with other spectral signatures. However, as previously applied, it only indicates that a mineral exists somewhere in an image that is several tens of km^2. This presents challenges for verification and validation, and for understanding geologic context.

Here we apply an innovative new version of FATT [7] to the detection of magnesite and serpentine in the Mars 2020 candidate landing sites, where the FATT technique is applied to groups of pixels, which we term an aperture, that move across the analyzed image. Using this approach, called Dynamic Aperture Target Transformation (DATT), we are able to both detect and locate minerals in CRISM data [7]. We use multiple apertures that vary in shape and only consider detections to be pixels where minerals are detected in all aperture shapes [7]. This allows us to detect the presence and location specific minerals within an image, which has not to our knowledge been done previously with FATT techniques.

FATT is best at detecting minerals with distinctive spectral signatures (e.g. phyllosilicates, carbonates, and sulfates [6]). Here we apply this technique to search for carbonate and serpentine within Mars 2020 candidate landing sites: NE Syrtis, Jezero crater, and Nili Fossae. We detect carbonate in NE Syrtis and both within and outside of the delta in Jezero crater. We detect serpentine in the eastern and western walls of the Nili Fossae trough and in Hargraves ejecta within the trough. Presence of serpentine may indicate the presence of an ancient hydrothermal system [8]. Carbonate on Earth forms in hydrothermal [8], diagenetic, and evaporative [9] settings.

Methods: The DATT analysis technique [7, 10] is applied to CRISM images covering the Jezero crater, NE Syrtis, and Nili Fossae Mars 2020 candidate landing sites. We overlay positive detections from DATT with positive detections from sparse unmixing analysis of the same image [7, 11]. Only pixels with detections in all DATT apertures and above a specific abundance in sparse unmixing are considered positive detections. The acceptance threshold of abundance for sparse unmixing is empirically determined by manually checking spectra of detections. Future work will automate this empirical threshold analysis process. We then ensure the accuracy of our detections by manually analyzing clusters of pixels with positive detections.

Results: Magnesite is detected both within and proximal to the NE Syrtis landing ellipse, primarily associated with the olivine-rich unit, as has been documented previously [12, 13] (Fig. 1). Magnesite is an alteration product of olivine in CO_2-rich environments. We detect carbonate both within and proximal to the Jezero crater delta (Fig. 2), which likely originated within the Jezero watershed [1]. The strongest detections of magnesite are associated with light-toned features within a paleochannel in the delta [14]. Goudge et al. [1, 14] detected carbonate using spectral parameters and detailed validation work within the Jezero delta, but their detections are more widely distributed than our detections. Their detections are all associated with stratigraphically higher units [14], while ours are associated with the stratigraphically higher units and those exposed in the tributary valley. There are more outcrops of carbonate in NE Syrtis compared to Jezero.

Though no carbonate is detected in the Nili Fossae trough, we do detect significant concentrations of serpentine associated with mounds, the eastern and western trough walls, and Hargraves ejecta within the trough. Of all three analyzed sites, Nili Fossae presents the most mineralogical evidence of paleohydrothermal systems due to presence of serpentine, making it the most astrobiologically intriguing site considered here.

Discussion & Conclusions: Integrated Dynamic Aperture Target Transformation and Sparse Unmixing (IDATTSU) is a promising technique for characterizing the presence and distribution of specific minerals within CRISM data [7, 10]. IDATTSU analysis of the Mars 2020 candidate landing sites has characterized the distribution of magnesite in NE Syrtis and Jezero crater as well as serpentine in the Nili Fossae trough.

This will allow for a more informed choice of final landing site location as well as rover traverse planning for optimal sampling strategy. Future work will continue to refine the IDATTSU technique to characterize the distribution of talc, hydrated silica, and sulfates within CRISM images. Mineral assemblage characterization will allow us to assess the geochemistry of the alteration environment that carbonate and/or serpentine formed in. IDATTSU has the potential to reveal and characterize significant quantities of undiscovered mineral deposits and assemblages on Mars.

Acknowledgements: Thanks to Jay Dickson for generating CTX mosaics for the Mars 2020 landing sites.

References: [1] Goudge, T. A. et al. (2015) *JGR Plan.* 120: 775-808. [2] Ehlmann, B. L. & Mustard, J. F. (2012), *GRL* 39: L11202. [3] Brown, A. J. et al. (2010) *EPSL* 297: 174-182. [4] Amador, E. S. (2017) *PhD Thesis*, U. of Wash. [5] Bandfield, J.L. et al. (2000) *JGR-Planet, 105,* 9573–9587. [6] Thomas, N.H. & Bandfield, J. L. (2017) *Icarus, 291,* 124–135. [7] Lin et al. (2018) *LPSC XVIX*, this conference. [8] Klein, F. et al. (2014) *Geo.* 42: 135-138. [9] Caruso, A. et al. (2015) *Palaeo*[3]. [10] Zhang, X. et al. (2018) *LPSC XVIX*, this conference. [11] Lin, HL. et al. (2018), *submitted*. [12] Bramble, M. S. et al. (2017) *Icarus* 293: 66-93. [13] Ehlmann, B. L. et al. (2008), *Science* 322: 1828-1832. [14] Goudge , T. A. et al. (2017) *EPSL* 458: 357-265.

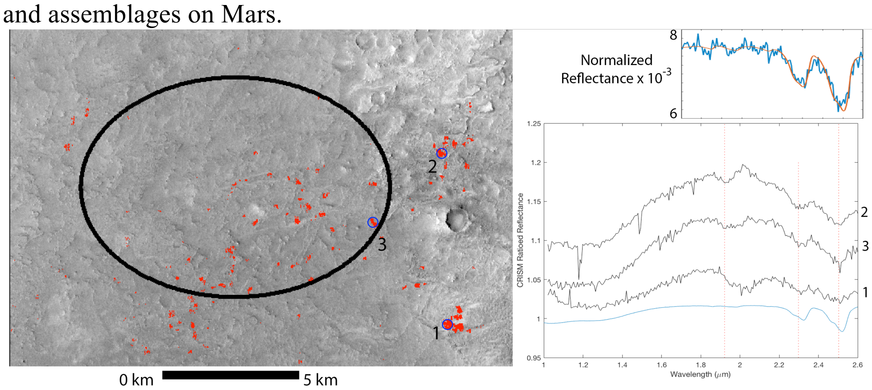

Figure 1 | NE Syrtis carbonate. IDATTSU carbonate detections shown in red (left), spectra of detections (lower right), and target transformation model fits (upper right). North is up. A laboratory magnesite spectrum is shown in blue. The spectra are taken from locations indicated by their number and a corresponding blue circle. The majority of carbonate is concentrated in the south eastern portion of the landing ellipse (black) and proximal localities. The dotted lines correspond to the 1.9, 2.3, and 2.5 μm band positions. CRISM images analyzed are FRT17B1B, FRT161EF, FRT18781, and FRT165F7.

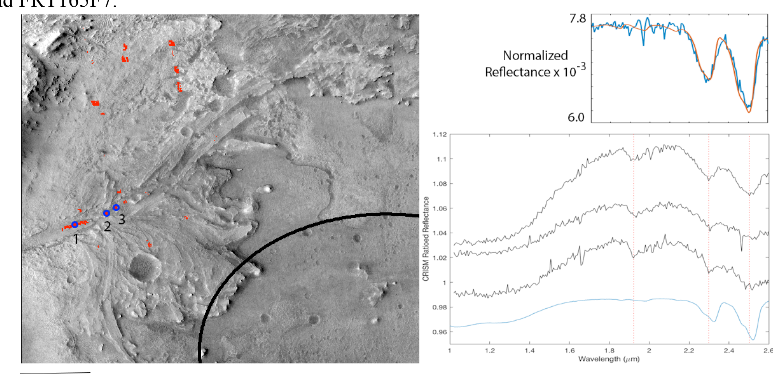

Figure 2 | Jezero crater carbonate. IDATTSU carbonate detections shown in red (left), spectra of detections (lower right), and target transformation model fits (upper right). North is up. A laboratory magnesite spectrum is shown in blue. The spectra are taken from locations indicated by their number and a corresponding blue circle. The strongest carbonate detections occur in the valley incising the westernmost portion of the delta. The dotted lines correspond to the 1.9, 2.3, and 2.5 μm band positions. CRISM images analyzed are FRT47A3, FRT5C5E, and FRS31442.

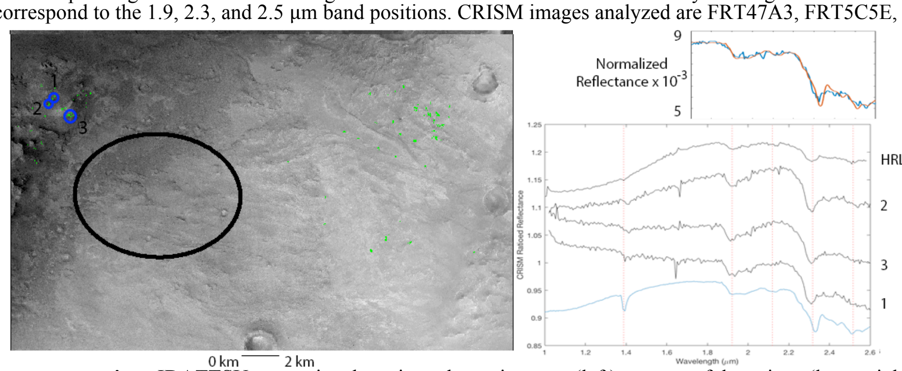

Figure 3 | Nili Fossae serpentine. IDATTSU serpentine detections shown in green (left), spectra of detections (lower right), and target transformation model fits (upper right). North is up. A laboratory serpentine spectrum is shown in blue. The spectra are taken from locations indicated by their number and a corresponding blue circle. The serpentine is concentrated on mounds, on the trough wall, and in Hargraves ejecta. The dotted lines correspond to the 1.39, 1.92, 2.12, 2.32, and 2.52 μm band positions. CRISM images analyzed are FRT64D9, FRTB012, and HRL95A2 (in spectra, not in map).