MINERALOGY OF MARTIAN LAYERED DEPOSITS: A GLOBAL STUDY. E. T. Putnam[1], A. A. Fraeman[2], and K. M. Stack[2], [1]Dartmouth College, Hanover, NH, Ethan.T.Putnam.18@dartmouth.edu, [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.

Introduction: The growing availability of high spatial resolution images from the surface of Mars has led to the identification of thousands of stratified outcrops across the martian surface (i.e. [1-3]). Many of these deposits are candidate sedimentary deposits that were likely subaqueously or subaerially desposited. Such deposits would provide a record of Mars' changing environmental history, and their mineralogy would reflect either (1) conditions on or near the surface when they were emplaced, or (2) conditions during diagenesis [1,2,3].

Here, we cross-reference a database of several thousand stratified deposits [1] with Compact Reconaissance Imaging Specrometer for Mars (CRISM) observations to systematically characterizerize the mineralogy of these deposits. We look for global spatial and temporal patterns in this data. The goal of this study is to understand how the mineralogical record preserved in these outcrops can be used to improve our understanding of Mars' climate evolution and the global trends in depositional and diagenetic processes.

Methodology: We began our investigation by investigating stratified deposits within Noachian/Hesperian basins identified in [1]. The decision to narrow our search to only these deposits reduced the total number of stratified deposits to study from >5,000 to a more manageable number. Basin fill deposits were chosen because they are most likely to be sedimentary, i.e. formed via transport, deposition, and cementation.

We cross-referenced this downselected database with available CRISM converage on the Planetary Data System (PDS), prioritizing deposits for which next generation CRISM Targeted Empircal Record (TER) products were available. These CRISM data types are artifact- and atmosphericially-corrected scenes in which data from the short- (~0.4 – 1.0 micrometer) and long-wavelength (~1 – 4 micrometers) detectors have been joined [4,5]. Spectral parameter maps [6] for both long and shortwave detectors were used to identify key diagnostic absorptions for minerals that might be present within each scene. We confirmed all candidate mineral detections by hand. To date, we have investigated CRISM results at over 80 stratified deposits.

Results: Figures 1 and 2 show the numbers of sites containing different minerals and their global distribution, respectively. Out of the 80 sites with CRISM coverage of stratified deposits, 19 had Fe/Mg phyllosilicates, 16 had poly-hydrated sulfates, 10 had mono-hydrated sulfates, 8 had hydrated silica, and 2 had hematite. Many sites had either no distinct mineral signatures or spectral features of major mafic minerals. No outcrops contained carbonates.

Valles Marineris and the Meridiani region contained almost half (39 out of the 80) of studied sites due to high densities of layered outcrops with coordinate CRISM coverage in those areas. 25 out of the 28 outcrops in Valles Marineris (89%) were found to have layers containing diagnostic mineral absorption features, versus 43 out of 80 (54%) in the entire dataset of layered outcrops. A variety of different mineral assemblages within individual sites were detected. Table 1 shows the 12 different combinations of diagnostic minerals found at sites.

Conclusions and Future Work: A large range of minerals and mineral assemblages associated with stratified deposits were detected, reflecting a wide diversity of primary depositional and secondary diagenetic environments on early Mars.

The greatest mineralogical diversity was found in Valles Marineris and the Meridiani region. This potentially reflects important role of diagenetic processes in those areas, possibly consistent with predictions by regional ground-water upwelling models [7,8]. Phyllosilicates were the most commonly found mineral group and were distributed globally, whereas other groups of minerals, namely sulfates and red crystalline hematite, were found almost only exclusively Valles Marineris and the Meridiani Region. This study found only one stratified deposit outside of these regions, Gale Crater, contained sulfates and minerals other than phyllosilicates. The non-mineralogically distinct layered deposits could either dust covered or composed of poorly crystalline materials, possibly compacted dust [9].

No carbonates were detected in our set of sites. Future work will investigate the implications of the lack of carbonates for Martian atmospheric evolution, especially constraints on P_{CO2} leading to formation of phyllosilicates over carbonates. Hematite was only found in the Valles Marineris area associated with sulfates and Gale crater [10]. Previous studies examining the association between hematite and sulfates in Valles Marineris interpretes hematite as a secondary diagenetic phase [i.e. 11, 12]. No evidence for stratified deposits analogous to early Earth's banded iron formations, i.e. containing evidence for possible primary hematite precipitates, were found. Future work will consider implications for this in context of atmospheric redox evolution. Continued work will also include investigations of 500+ additional deposits as well as assembling a more complete set of age estaimte constraints for the studied sites. This will allow for the mineralogy of these outcrops to be studied through time, improving the specificity of the atmospheric implications of this work.

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Fe/Mg Phyllosilicates	Poly-hydrated sulfates	Mono-hydrated sulfates	Hydrated silica	Red crystalline hematite
x				
x	x			
		x		x
			x	
x			x	
	x		x	
		x		
	x			
	x	x		x
		x	x	
	x	x		

Table 1: (Above) Combinations of diagnostic mineral groups found within different single sites. The range of different combinations imply a variety of enivronmental histories.

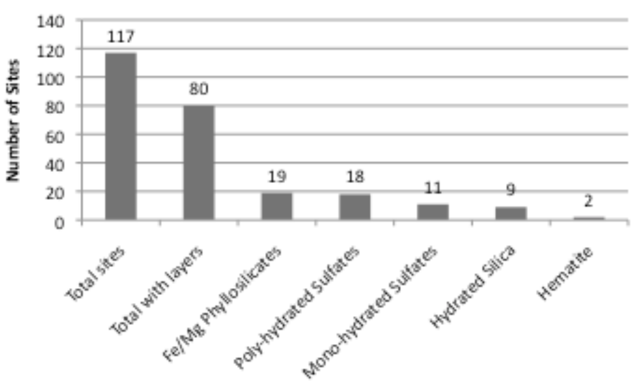

Figure 1: (To left) Numbers of sites where different minerals were found. Sites with multiple minerals present have been put in both columns. While overall more sites contained sulfates, they were far more regionally restricted.

Figure 2: (Below) Map of clearly layered deposits and minerals found. Note the diversity of mineral assemblages and the clustering of diverse sites. The base map is Mars Orbital Laser Altimeter (MOLA) elevation.