DISCOVERY OF DEFORMATION BAND DAMAGE ZONES ON MARS. C. H. Okubo, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ, 86001, cokubo@usgs.gov.

Introduction: Deformation bands are useful indicators of host rock microstructure, stress history, and fluid flow potential in terrestrial reservoir rocks [e.g., 1]. On Mars, clusters of deformation bands have been previously recognized [2,3], yet their utility in understanding Martian geology remains contentious. Much deformation band research on Earth has focused on examples in quartz-rich sandstone, yielding the false impression that deformation bands are restricted to host rock compositions that are not observed on Mars. Further, a lack of evidence for the occurrence of deformation bands around faults has sustained the idea that these bands do not typically form in Martian lithologies; if deformation bands do indeed occur on Mars, then they should be found within the high-strain environments around faults in clastic sedimentary deposits. This work addresses the latter issue by documenting the discovery of deformation band damage zones around faults in Martian sedimentary rocks using high-resolution imaging and topographic data (Fig. 1).

Image interpretation: In west Candor Chasma, CTX observations reveal a ~15.5-km-long fault-related damage zone within the layered deposits (Fig. 1a,b). A fault-related damage zone is defined in this paper as the volume of deformed rocks around a fault that developed during the evolution of slip along that fault. This damage zone has a maximum apparent width at the surface of ~200 m. Stereoscopic CTX observations (P02_001641_1734_XI_06S075W; P03_002063_1733_XI_06S075W) show that stratigraphy is offset in a normal sense across this damage zone and that this damage zone has an overall dip to the south.

A 5.36-km-long section of the damage zone is imaged in stereo by HiRISE (PSP_001641_1735; PSP_002063_1735). These data show that the interior of the damage zone consists of a series of ridges that are up to ten meters in width and tens to hundreds of meters in length (Fig. 1c, feature 1). Ridges also commonly define the northern and southern boundaries of the damage zone (Fig. 1c, features 2 and 3). In plan view, the ridges exhibit a minor degree of sinuosity and internal ridges usually trend subparallel with the northern and southern boundaries of the fault zone.

Much of the damage zone is darker in tone than the

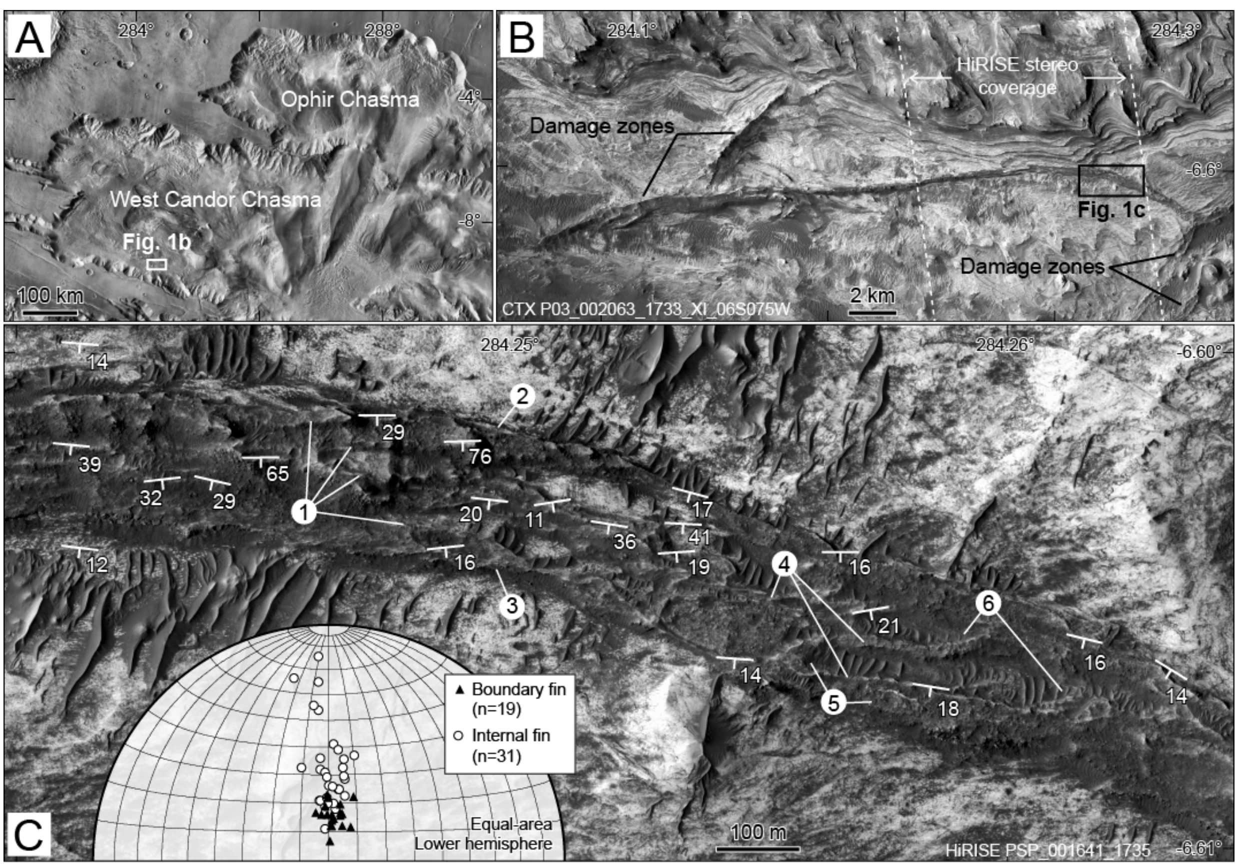

Fig. 1. Deformation band damage zone discovery area in west Candor Chasma, Mars. Illumination is from the left in all parts. A) Location of the study area. THEMIS day IR basemap. B) The damage zone discussed in this paper. C) Orientations of damage zone fins and enumerated features discussed in the text. Inset stereonet shows poles to planes fit to the damage zone fins.

bedrock of layered deposits. In HiRISE's color swath, the dark-toned areas of the damage zone are similar in hue to the sand sheets and dunes that are common within the damage zone and throughout the study area. CRISM spectral summary products (from HRL000033B7) reveal that the composition of the dark-toned areas within the damage zone is consistent with an olivine and pyroxene-dominated mineralogy mixed with sulfates [e.g., 4], similar to the sand sheets and dunes elsewhere. CRISM observations also show that the light-toned areas between the ridges have a similar spectral response as the surrounding sulfate-rich, light-toned layered deposits. Thus strong evidence for diagenetic cementation and abundant clay content are not observed within the damage zone.

Fins, or inclined layers, of light-toned rock are exposed along the crests of many damage zone ridges. These fins appear to largely hold up the ridges, similar to resistant bedding within a hogback. Some ridges are composed entirely of this light-toned fin rock. These fins and ridges are the defining features of the fault zone, as other discontinuities such as joints or lineations are not apparent. Therefore the orientations of the light-toned fins are measured in order to gain insight into the internal structure of the damage zone.

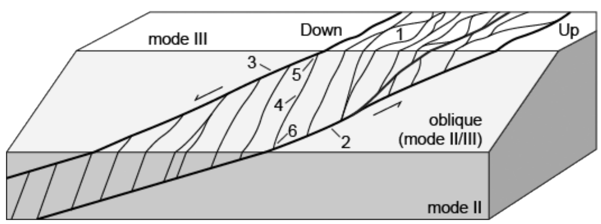

Fig. 2. Block diagram of a deformation band ladder structure with a normal sense of offset and shallow dip. Enumerated features are discussed in the text.

Structural analysis: A DEM is constructed from the HiRISE stereo pair covering this area to facilitate quantitative characterization of this damage zone's structure. The DEM is built following the methodology of [5] and has 1 m post spacings.

The fins are found to dip toward the south, with the magnitude of dip varying with position within the damage zone. The mean dip of fins along the northern and southern boundaries of the damage zone is 16° ± 3°, whereas fins within the damage zone have a steeper mean dip of 33° ± 3° (Fig. 1c inset).

The moderately sinuous ridges within the fault zones (Fig. 1c, feature 1) are consistent with the inosculating geometries of linking band clusters within a deformation band ladder structure when viewed in the mode III direction (Fig. 2, feature 1).

The southerly dip direction of ridges along both the northern and southern boundaries of the damage zone (Fig.1c) is consistent with the dip of the outermost bounding band clusters of a ladder structure that developed under conditions of dip-slip displacement (Fig. 2, features 2 and 3).

The ridges within this damage zone also dip to the south, but at angles that are generally steeper than the ridges along the boundaries of the damage zone. This is consistent with the dip of linking band clusters within a shallowly- and southward-dipping ladder structure with a normal sense of offset, as viewed in the mode III direction (Fig. 2, features 2–4).

Exposures of the damage zone in slightly steeper terrain show that some internal fins extend from one damage zone boundary and intersect the opposite boundary (Fig. 1c, feature 4). This is consistent with the linking band cluster in a deformation band ladder structure when viewed in an oblique mode II/III direction (Fig. 2, feature 4) – the steeper terrain provides the oblique viewing geometry.

At the intersection between a linking band cluster and a bounding band cluster on the hanging wall side of a ladder structure, the acute angle is within the hanging wall of the linking band (Fig. 1c, feature 5). Further, at the intersection between a linking band and a bounding band on the footwall side of a ladder structure, the acute angle is in the footwall of the linking band (Fig. 1c, feature 6). This is again consistent with the intersection angles for a ladder structure (Fig. 2, features 5 and 6).

Taken together, these interpretations point to the architecture of this damage zone being consistent with that of a deformation band ladder structure. As with deformation band damage zones on Earth, the bounding and linking structures (the 'fins') within the ladders would be comprised of clusters of deformation bands, rather than individual bands.

Implications: These results provide the first documentation of fault-related, deformation band damage zones on Mars. In addition to previous findings of deformation bands on Mars [2,3], this work demonstrates that deformation bands are a relevant component in structural and tectonic studies of the equatorial layered deposits.

References: [1] Fossen H. et al. (2007) *J Geol Soc*, 164, 55–769. [2] Okubo C. H. et al. (2009) *GSA Bull*, 121, 474–482. [3] Okubo C. H. (2010) *Icarus*, 207, 210–225. [4] Murchie et al. (2009) *JGR*, 114, E00D05. [5] Kirk et al. (2008) *JGR*, 113, E00A24.

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