BRECCIA DIKES IN IMPACT CRATERS ON MARS: EXPOSURE ON THE FLOOR OF A 85-KM DIAMETER CRATER AT THE DICHOTOMY BOUNDARY. J. W. Head[1] and J. F. Mustard[1], [1]Department of Geological Sciences, Brown University, Providence RI 02912 USA (james_head@brown.edu).

Introduction: Recent Mars exploration has obtained high-resolution imaging, spectroscopy and altimetry data that permit the further analysis of impact cratering deposits in much more detail than previously possible. These new data, combined with an increased understanding of both the impact cratering process in general and deposition/exhumation processes on Mars, has led to renewed interest in the role that Mars can play in further decoding important aspects of the cratering process. In this abstract, using criteria developed from a synthesis of breccia dike occurrences in terrestrial craters [1], we report on the discovery of a complex system of ridges on the floor of an impact crater that we interpret to be breccia dikes formed in concert with the impact cratering event and subsequently exhumed. We document the characteristics of these features, show the nature of the overlying deposits and their exhumation, assess their role in the cratering process through comparison with terrestrial breccia dikes, and develop criteria for the further recognition of these features on Mars.

Geological Setting: The dichotomy boundary, separating the northern lowlands from the southern uplands, is an area of enhanced erosion and degradation of a variety of landforms, including impact craters [2]. We have examined a row of four aligned but non-overlapping Noachian-aged impact craters, each 85-100 km in diameter, and extending along and adjacent to the dichotomy boundary over a distance of about 400 km (Fig. 1). Each impact crater shows a somewhat different state of degradation including heavily fractured floors, graben cutting the crater rims and floors, sapping channels and valleys eroding floors and rims and breaching craters, exhumed and stripped deposits on crater floors, completely breached crater rims, and extensive eolian deposition. We focus here on the analysis of complex arrays of ridge structures exhumed and exposed on the floor of the 85 km diameter crater designated C in Fig. 1.

Geological Relationships and Stratigraphy on the Floor of Crater C: The uppermost youngest materials on the floor of the crater are of eolian origin and consist of a large low-albedo patch of dunes in the northern part of the floor, and abundant relatively high-albedo linear and arcuate dunes arranged in clusters and patches elsewhere on the crater floor (Fig. 2-4). The very young age of these dune deposits is indicated by the apparent lack of superposed craters. Underlying these eolian deposits is a regionally relatively smooth flat-lying medial unit that occurs over a significant portion of the crater floor. Examination of this unit shows that it is composed of several flat-lying layers that appear to have been partially stripped, exhuming successively underlying layers in this unit. In some places, this medial unit has been completely removed, exposing the lowermost unit, which consists of a distinctive network of lattice-like ridges. The thickness of the flat-lying medial unit is of the order of hundreds of meters and individual subunits within it range from a few, to a few tens of meters thick. The uppermost part of the medial unit is slightly hummocky and moderately cratered. Exposed surfaces of subunits lower in the medial unit show a higher crater density, and craters on the lowermost subunit have been filled by the next overlying unit and subsequently exhumed. The lowermost medial subunit is transitional with the basal lattice-like unit with the ridges in the lattice appearing at the margins of the unit and becoming progressively exhumed with greater distance from the contact (Fig. 2, 3, lower corners). The medial unit weathers to large irregularly-outlined areas with stepped and terraced margins (representing the subunits), and rounded to oval mesas up to ~1 km in diameter (Fig. 2, 3). In summary, the nature of the medial unit suggests that it is flat lying crater floor fill, that it represents a series of filling and exhumation events, and that the materials making it up is easily eroded and removed, most likely being the source of the upper unit dune deposits. On the basis of geological relations elsewhere on Mars, deposits characterizing crater fill might include initial impact crater ejecta fallback and melt, subsequent distant ejecta, mass wasting, atmospheric dust and ice deposits, fluvial deposits, and volcanic tephra and lava flows.

Geological Characteristics of the Lowermost Lattice-Like Unit: The lowermost unit contains a distinctive set of linear ridges of broadly similar width forming a lattice-like pattern. Ridge exposures ranged from ~1-4 km in length and ~50-100 m in width; if the ridge represented a dike, this width certainly overestimate the actual dike width due to the presence of a flanking erosional debris apron. Individual ridges are generally straight to slightly curving, (Fig. 2-4) but some are slightly sinuous (Fig. 4, middle). In some cases they form broadly parallel ridges separated by hundreds of m to a km (Fig. 2, 4); in others, these ridges are cross-cut by near-orthogonal ridges forming a box or lattice-like pattern (Fig. 2, center; Fig. 4, right). Some ridges terminate abruptly against other orthogonally-oriented ridges (Fig. 3, upper right). Others bifurcate (Fig. 2, middle; 3, upper middle), and a few show possible en echelon structure (Fig. 3, right). Cross-cutting relationships are often clearly observed, but as yet no clear relationships have been established for sequential developments of trends. Near-orthogonal terminations suggest faulting and lateral offset, but exposure is insufficient to locate and restore possible offsets. The location of these images (Fig. 2-4) is from the crater floor, extending from the base of the wall to the edge of the central peak region. The general orientation patterns are crudely radial and concentric to the crater, and more detailed analysis of orientations is underway.

Comparison to Terrestrial Breccia Dikes and Interpretation: On Earth, breccia dikes are common in eroded complex craters in a wide range of target rocks [3-5], range up to tens of m in width and tens of km in length, occur in complex honeycomb-like patterns and are often offset along late-stage crater-related faults; individual dikes can undulate in width and branch and bifurcate along strike. These characteristics are very similar to those of the ridges prominently occurring in the exhumed basal unit on the floor of the 85 km diameter crater C. On the basis of these strong similarities, we interpret these ridges to be the erosional manifestation of breccia dikes formed below the floor of the crater during the impact event that created crater C, and subsequently exhumed.

The further documentation of the presence and nature of breccia dikes on Mars will help in documenting the nature of impact cratering processes there and aid in assessment of the levels and depths of exhumation processes. The presence of networks of breccia dikes below complex crater floor floors also has important implications for the structure of the crust of Mars. For example, models of Mars crustal hydrology need to take into account the development of significant lattice-like networks of solid dikes in considering the permeability of the impact-formed megaregolith. On Earth, breccia dikes are often associated with key mineral resources (e.g., Sudbury) and are also clearly related to late-stage thermal and mechanical readjustments of impact craters, thus forming candidate longer-term distributed heat sources analogous to magmatic hydrothermal vents. Upcoming very high spatial and spectral resolution instruments on MRO have the capability to analyze the geology and mineralogy of these type of breccia dikes in detail.

References: [1] J. Head and J. Mustard (2005) V-B 42, this volume. [2] K. Tanaka (2004) LPI Contrib. 1213, 68. [3] P. Lambert (1981) Proc. Multi-Ring Basins, LPI, 12A, 59. [4] T. Kenkmann (2003) EPSL, 214, 43. [5] C. Wood and J. Spray (1998) MAPS, 33, 337.

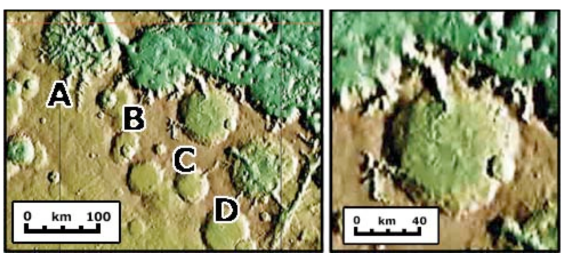

Fig. 1. (a) Four impact craters with different states of degradation at the dichotomy boundary; A-D, left to right. (b) Crater C.

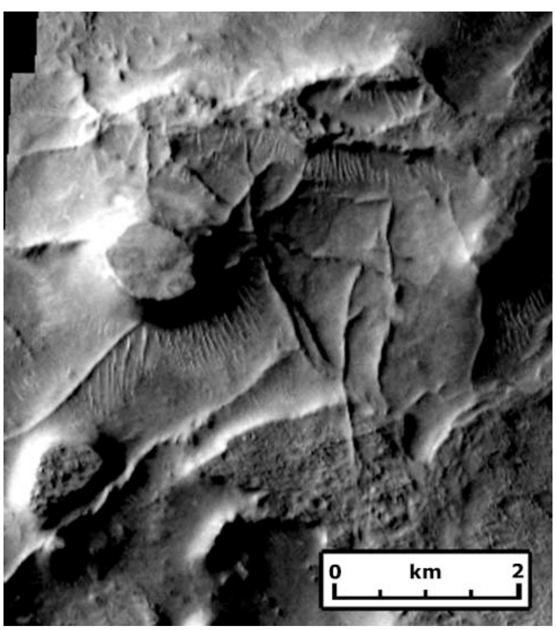

Fig. 2. The floor of crater C; THEMIS Image V12779010.

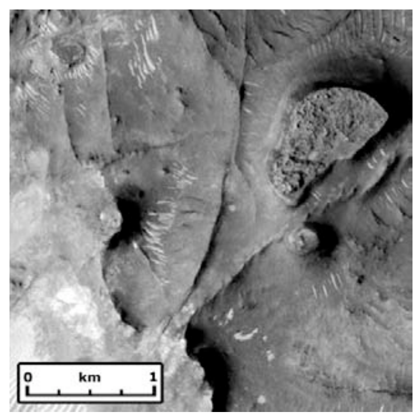

Fig. 3. The floor of crater C; MOC Image R18/00213.

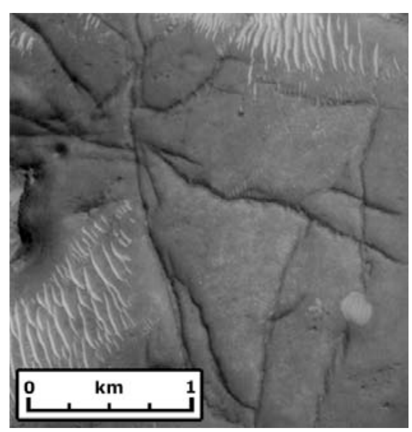

Fig. 4. The floor of crater C (central part of Fig. 2); MOC Image E14/01582.