UNCONFORMITY SURFACES OF THE KIMBERLEY REGION AND THEIR SIGNIFICANCE ON SEDIMENTOLOGICAL EVOLUTION OF GALE CRATER, MARS,
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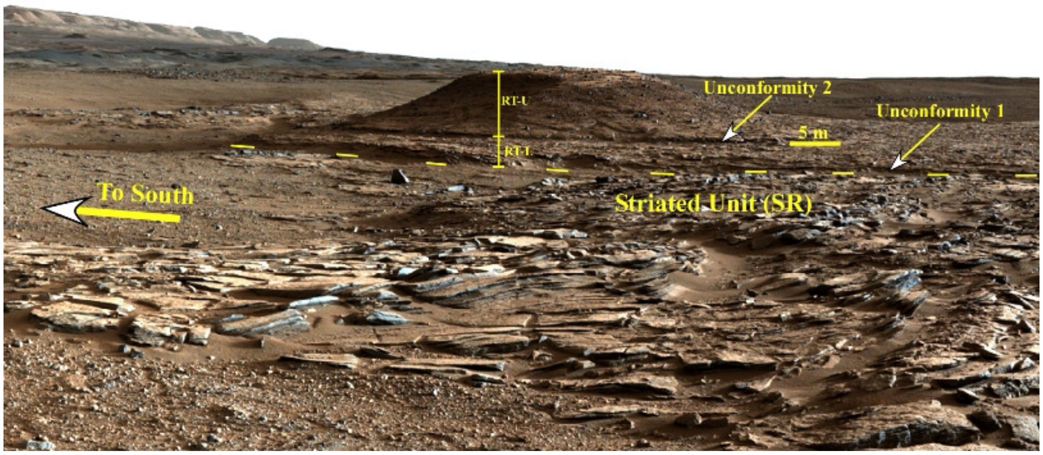

Fig. 1. The photo (looking west) is a MastCam image acauired by the Curiosity rover on Sol 590 at the Kimberley region. It shows two of the three unconformites discussed in this study. Unconformity 1 (dashed yellow line) is between the Striated Unit (SR) and the lower interval of Rugged Terrain Unit (RT-L). Unconfomity 2 is between the lower, and the upper intervals of RT Unit, RT-L and RT-U, respectively.

Introduction: Gale crater, Mars, formed by an impact during Late Noachian to Early Hesperian time interval [1]. Soon after, it was filled by nearly 5 km of sedimentary rocks [2-4]. Excavation resulted in the exposure of sedimentary rocks on the crater floor and around the margins of its central mound, Mt. Sharp [1-4]. Six orbitally recognizable units are identified in the landing site ellipse of the Mars Science Laboratory rover: Curiosity [5 - 9]. Three of these units, the Hummocky Plains (HP), the Rugged Terrain (RT), and the Striated (SR) units, are exposed at the Kimberley region (Fig. 2). Study shows three major unconformities in this area (Figs. 1-3). HiRise images suggest that these unconformities occur throughout and possibly beyound the Kimberley area (Fig. 2). Identification of these unconformites has a major significance on sedimentological evolution of Gale crater.

Characteristics of Orbital Units: The SR Unit is light toned on orbital images, clearly layered, and has a consistent strike of about N65ºE and a dip of 10-20º SE (Fig. 2). The RT Unit is medium toned, shows rough surface characteristics, and appears masssive to thickly bedded on orbital images (Fig. 2). It strikes roughly N-S and has a gentle and variable dip that is about 2-3°W at this location. It cross-cuts the SR Unit (Figs. 1-3).

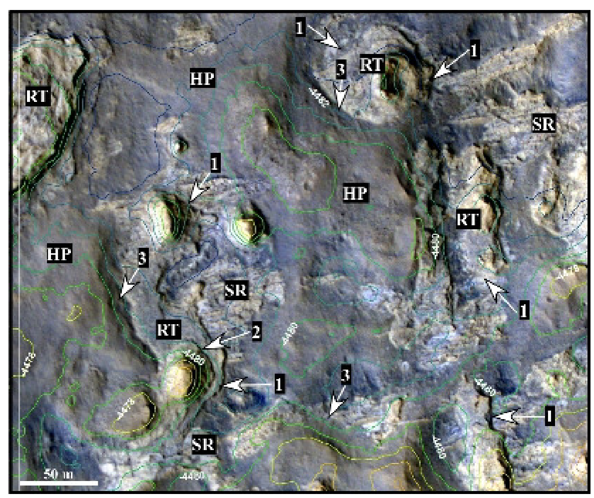

Fig. 2. HiRise image of the Kimberly region. HP = the Hummocky Plains Unit, RT = the Rugged Terrain Unit, SR = the Striated Unit. Arrows, 1, 2, and 3 point to the unconformities in this area. Colored lines are elevations contour lines.

The RT unit consists of a lower (RT-L) and an upper (RT-U) interval at the Kimberley area (Figs. 1, 3). The HP Unit is dark in color, appears smooth, and does not show layering on orbital images (Fig. 2).

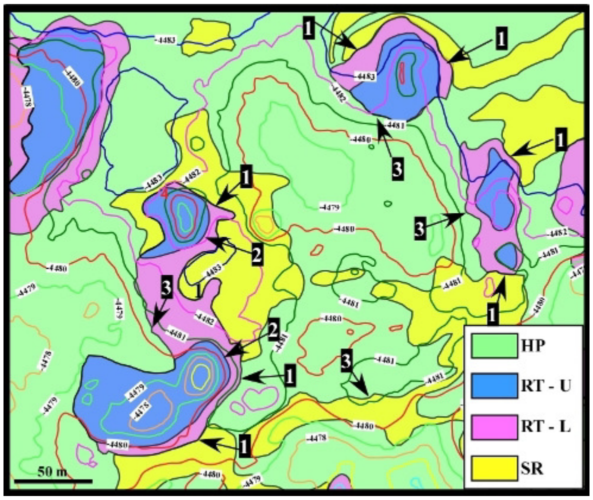

Fig. 2. Geological map of the Kimberley region based on the Hirise map shown in Figure 2. HP = the Hummocky Plains Unit, RT - L = the lower interval of the Rugged Terrain Unit, RT - U = the upper interval of the Rugged Terrain Unit, SR = the Striated Unit. Arrows 1, 2, and 3 point to unconformities discussed in this study. Colored lines are contours and numbers are elevations in meters.

The Unconformities: Three unconformites are recognized at the Kimberely region (Figs. 2-3): one between the SR Unit and the RT-L (unconformity 1), one between the lower and the upper intervals of RT Unit (unconformity 2), and one between the RT and HP units (unconformity 3). The most important of these is unconformity 1. It was recognized by variations in latteral continuity, cross-cutting relationships, and changes in attitude (strikes and dips) of SR and RT strata. The regional dip of layers indicate that the SR Unit was deposited on a south-sloping surface. That is, its sediments were derived from the north and were deposited in a lake when Gale crater was being filled [10].

However, our study indicates that the RT Unit was deposited on a north-sloping surface that had formed after the erosion of the SR Unit and its overlying strata. This relationship suggests that the RT Unit formed after the deposition of the SR Unit, its burial, and subsequent excavation and erosion. That is, the north-sloping surface on top of the SR Unit is Mt. Sharp's exhumation surface. This means that sediments of the RT and HP units were derived from Mt. Sharp after excavation of Gale crater. The missing geological time along unconformity 1 is not constrained by the available data. But it could be several hundred million years.

Interpretations: The identification of the proposed unconformities has a major significance in sedimentological interpretation of Gale crater. They divide the observed strata into stratal packages which formed at different time by different process. For example, the unconformity 1 separates the SR Unit from the lower interval of the RT unit (RT-L). The SR Unit and its time equivalent the Murray formation, not seen at the Kimberely region, were deposited in a lake during the filling-phase of Gale crater [see 10]. However, the lower interval of the RT unit was deposited after the excavation of the crater and exhumation of Mt. Sharp. Here is a simplified list of events from the oldest to the youngest: (1) deposition of the SR Unit, (2) deposition of strata that overlied the SR Unit and eventually filled Gale crater [see 2-4], (3) erosion of most of the SR unit and strata which overlied it resulting in the formation of unconformity 1, (4) deposition of RT-L, (5) erosion of part of RT-L layers forming unconformity 2. (6) deposition of RT-U, (6) erosion of part of RT-U and formation of unconformity 3, (7) deposition of the HP Unit, and (8) erosion of the HP Unit (the current erosion surface).

References: [1] Grant et al. (2014), GRL, 41, 1142. [2] Malin and Edgett, (2000), Science, 290, 1927. [3] Anderson and Bell III, (2005), Mars, 1, 1. [4] Milliken et al. (2010) JGR, 37, doi:10.1029/2009GL041870. 2010. [5] Grotzinger et al. (2014) Science, 243, doi: 10.1126/science.1242777. [6] Calef III, et al. (2013) LPS XXXIV, [7] Rice et al. (2013) LPS XXXIV, [8] Stack, et al. (2013) LPS XXXIV, [9] Sumner et al. (2013) LPS XXXIV, [10] Grotzinger et al. (2015), Science, 350, doi.org/10.1126/science.aac7575.