ICE-RIND OR WHY THE VERTICAL EROSION OF MARTIAN FLUVIAL VALLEYS IS NOT COHERENT WITH THEIR SLOPES N.A. Cabrol, and E.A. Grin, NASA Ames Research Center, SST 245-3, Moffett Field, CA 94035-1000

Martian Fluvial Valley Systems (MFVS) testify the former abundance of liquid water near the surface as most valleys are in ancient terrains [1]. Simple topographic measurements and physical models provide strong arguments for sapping formation vs. surface runoffs. The amount of material removed measured from topography [2] coupled with models of regolith porosity [3] provide estimates for aquifer discharge. The results is that the amount of water that could have been contained in aquifer reservoir is inadequate to carve the deep valleys even with generous assumption on the erodability of the regolith. Magmatism and cratering [4] are advocated as striggers for aquifer recharge. Most valleys are currently U-shaped and display a flat-wide-smooth-like floor generally interpreted as sediment deposits. The widening of the valleys by wall-waste material is subsequent to the wall steep formation by vertical erosion [5]. A 0.11 depth-to-width ratio for small valleys is considered [5]. V-shaped geometrical models [6] radar-derived cross sectional profile [7] and one-dimensional photoclinometry [8] allow to assume channel slope (0.2 to 0.3%) for short segments of valleys. The reconstruction of graded longitudinal profiles based on geometrical models of valleys illustrates that once the streams were deeper than the present valley floor [8]. Generally, the available topographic data to derive cross sectional profile are not enough accurate to determine a precise full-length longitudinal profile and to determine the volume of transported sediments unless making assumptions on channel slope.

Fluvial valley formation has to be considered primarily by linear erosion produced by stream until the achievement of a longitudinal graded profile which occurs when it is neither eroding nor depositing material at any point along its course. The longitudinal profile usely illustrated by an ideal simple logarithmic curve [10] consists of continuous concave curves just steep enough to transport the fluvial load from the headwater (greatest curvature) to the outlet (base level). The steep gradient as normally seen in surface systems on Earth just downstream of the watershed is not necessarly observed on Mars because the melting sapwater emerges at the base of the valley wall. Linear erosion is explained by terrestrial-like laws adapted to martian gravitational acceleration [11,12]. The laws are physically the same for Mars. For this reason, the dissimilarity of valley formation on Mars is here demonstrated to be caused by permafrost bed-material substratum parameters that effect erosion rates beside geometric and stream-power parameters. The amount and duration of water discharge are inadequate to explain the excessive vertical erosion of the valleys. This vertical erosion is not coherent with the longitudinal valley slopes averaging only to 0.2%. On Mars, the valleys penetrate with a continuous slope deeply into the aquifer reservoir [7]. We argue that the excessive vertical erosion of the valley full length is caused by the erosion of a thick ice-rind which mantled the wetted perimeter of the river-bed. Arctic analogs (Barents Islands, NE Spitzberg) in Pleistocene permafrost areas [13] suggest that the martian upper regolith could be fully interspersed with ice-filled clefts. In our model, the ice-rind is a lattice structure locates under the valley floor. The ice-rind may extend under the base of the valley walls where it induces the proposed viscuous creep of near surface material [14,15].

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Periglacial Arctic models (Barents and Edge Islands ; Storfjord, SE Spitzberg) suggest that the proposed martian ice-rind is similar to a thick (a few hundreds of meters) lentoid structure formed by a lattice of ice lens-shaped [13] fine-grained regolith material [7] associated with pipkrakes (ice-needles) [13]. As the porosity of the megaregolith decreases exponentially with depth [3,16] the ground-ice is most likely located in the upper megaregolith layers. The ice-rind thins down by evaporation through the porous regolith and by mechanical erosion (fluvial activity). The upward thrust of remaning ground ice regenerates the ice-rind until the drain out of the icy reservoir. This process applied to Mars is accelerated by the high hydraulic conductivity of the regolith [17]. Under the valley floor, the ice-rind exposes a dislodged face caused by the melting of the lattice structure. This facilitates the mechanical work of the river by superficial thawing off of the undermass of its wetted perimeter. This mechanism incorporates the debris of the dislodged material into the fluvial floor and carry them away without the necessity of a strong stream power (function of the discharge and flow velocity which depends on the slope). This process of valley formation allows to expect that the fluvial sediments are composed of fine-grained size material without pebbles which are extracted from the deep mass of the regolith. Deep extracted fluvial sediments should record the history of the martian paleo-environment. Our model could be tested by the high resolution imagery of the valley floors by Mars Global Surveyor imagery system.

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