FROM TOPOGRAPHY PROFILE DIAGRAMS TO THE EVOLUTION OF OCEANUS BOREALIS: PROPOSAL OF A STRATEGY THAT MAY RESULT IN THE FORMAL PROOF OF MARTIAN OCEAN RECESSION, TIMING AND PROBABILITY. G. Salamunićcar, AVL-AST d.o.o., Av. Dubrovnik 10/II, 10020 Zagreb, Croatia, Europe, gsc@ieee.org.

Introduction: Papers about ocean on Mars published after the proposal of Contact 1 and 2 [1], can basically be divided into two groups. The first one is based on shoreline theory, but unfortunately, shorelines were not found in required amount. However, papers from the second group, while mostly discussing whether Contact 1 or 2 [2] is better approach, also proposed many additional indicators that ancient ocean may existed on Mars. Some of them are: spiral beaches [3], sedimentation [4], hydraulic and thermal arguments [5], outflow channels and features related to the evolution of standing bodies of water (polygons, lobate impact craters) [6], features consistent with the shoreline interpretation [7], impact craters [8], fluvial valleys [9], MEGAOUTFLO hypothesis [10], MOLA data [11, 12], tsunami generation and propagation [13], glaciers, fluvial channels and gullies [14], MGS data [15], erosion features that might be ancient coastal terraces [16], influence on planetary climate [17], etc. This is also in consistence with other work done more recently [18], including the proposal that in the early history of Mars even larger ocean existed up to the named Contact 0 [19]. On the other side, discovery of large number of buried impact craters all over the planet surface [20-27], indicates that young sediment covers much older surface all over the northern lowlands. While this is very important discovery, it should be noted that it is not a proof that ocean has not existed on Mars. E.g., very large impactor can leave crater even if ocean is 10 km deep. Heavy bombardment at the very early beginning of the planet evolution could also create those (possibly oldest) craters, at the time when surface of the planet was too hot for water to exist in liquid state. Even the much denser atmosphere that would include the water from the hypothetical ocean can not protect the surface from the impactors if the bombardment is too strong. However, once this process is over and surface of the planet cold enough so that water can exist in the form of possibly large ocean, it would prevent most of the impactors to leave craters over the territory it covered. Even today, such global influence on crater distribution has to be detectable using mathematical analysis, as proposed in [28]. However, while like any other mathematical theory the approach is applicable generally, it still needs to be formally proved that it is also applicable to Mars. As the first step, Topography Profile Diagrams (TPDs) representation of topography and correlated values were described [29, 30, 31] showing high correlation between density of craters and topographic altitude. Additionally, it is also shown that this correlation is not consequence of processes local to only some parts of planet surface, but of some global process [32]. In this paper, possibility that this global process was an ocean will be investigated.

From TPDs to the evolution of ocean: TPDs and associated, Topography Profile Curve (TPC), Density-of-Craters Curve (DCC), Filtered DCC (FDCC) and Level-of-Substance-Over-Time Curve (LSOTC) are described in [29]. DCC and FDCC can be computed in more than one way, so they were additionally described in [30] and [31]. In this paper, LSOTC will be further elaborated. If the assumption that ocean primarily caused noted correlation is correct, this curve actually represents how level of ocean was changing over time. Looking at Fig. 1, we can start with a point on FDCC (full line) where we have 90% of the maximal density of craters. The 10% smaller density of craters actually means that until the time when 10% of craters were already created, territory at this altitude was covered by the ocean, and after this time it was not. The altitude itself can be read from the associated (TPC) (dash-dash line). Once this is done, we can construct point on LSOTC (dash-dot-dot line), where x coordinate is time measured as a percentage of craters already created, and y coordinate value we can read from the TPC. Accordingly, for the each succeeding point from the DCC, we can construct one point on LSOTC, and so we can reconstruct the evolution of ocean over the complete planet history. For TPDs from Fig. 1 used for the first computations published in [28], results are shown in Fig. 2 and 3. Later computation as shown on TPDs from [29-32] offers more precise results, however the principles described here are the same. It should also be noted that ocean was modeled as something that offers infinite resistance to impactors, while the real ocean would have some finite resistance, meaning that actual level of the ocean was even larger then here computed. On the other side, atmosphere provides additional shielding from impactors, meaning that if we take only this additional factor also in computation, actual level of the ocean was smaller that computed. Those errors compensate one another, but not completely. Resistance of the deep ocean is however much higher than the resistance of the atmosphere and those errors difference. That means that even this simplest model offers satisfying first approximation of the actual values.

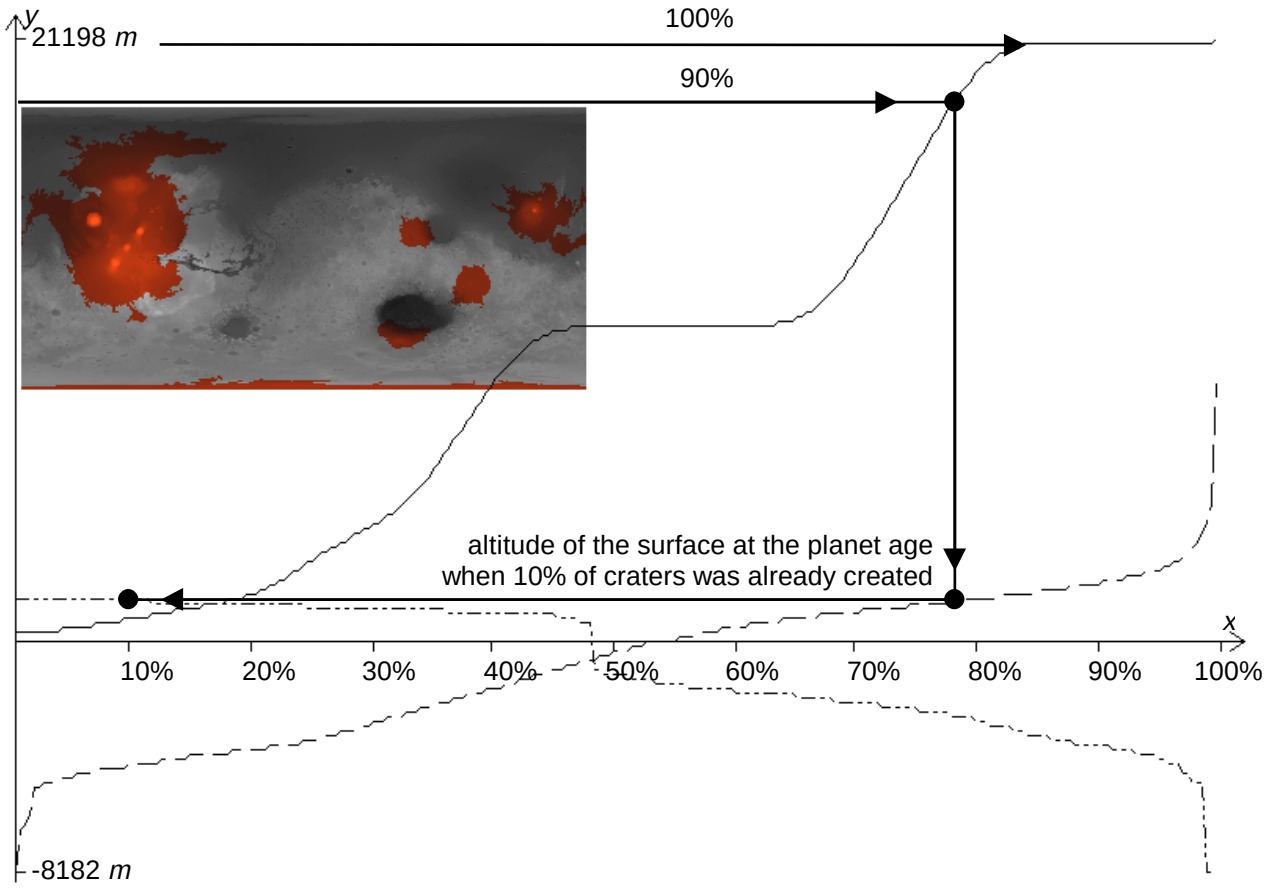

Figure 1: TPDs for the topography without regions marked as red, 1/32° MOLA data and 9496 craters data-set.

Conclusion: To prove that ocean existed on Mars using some direct approach will perhaps never be possible. However, this can be done if it is possible to prove that nothing except the ocean could have caused correlation shown on TPDs. The first step is to enumerate everything else that at least in theory could have caused found correlation, like e.g. atmosphere influence [33], tectonic movements [34], lava flows, sediment, etc. Then, the second step is to prove that no such alternative physical process caused the correlation. If both can be achieved, formal proof of Martian ocean recession, timing and probability will be achieved too.

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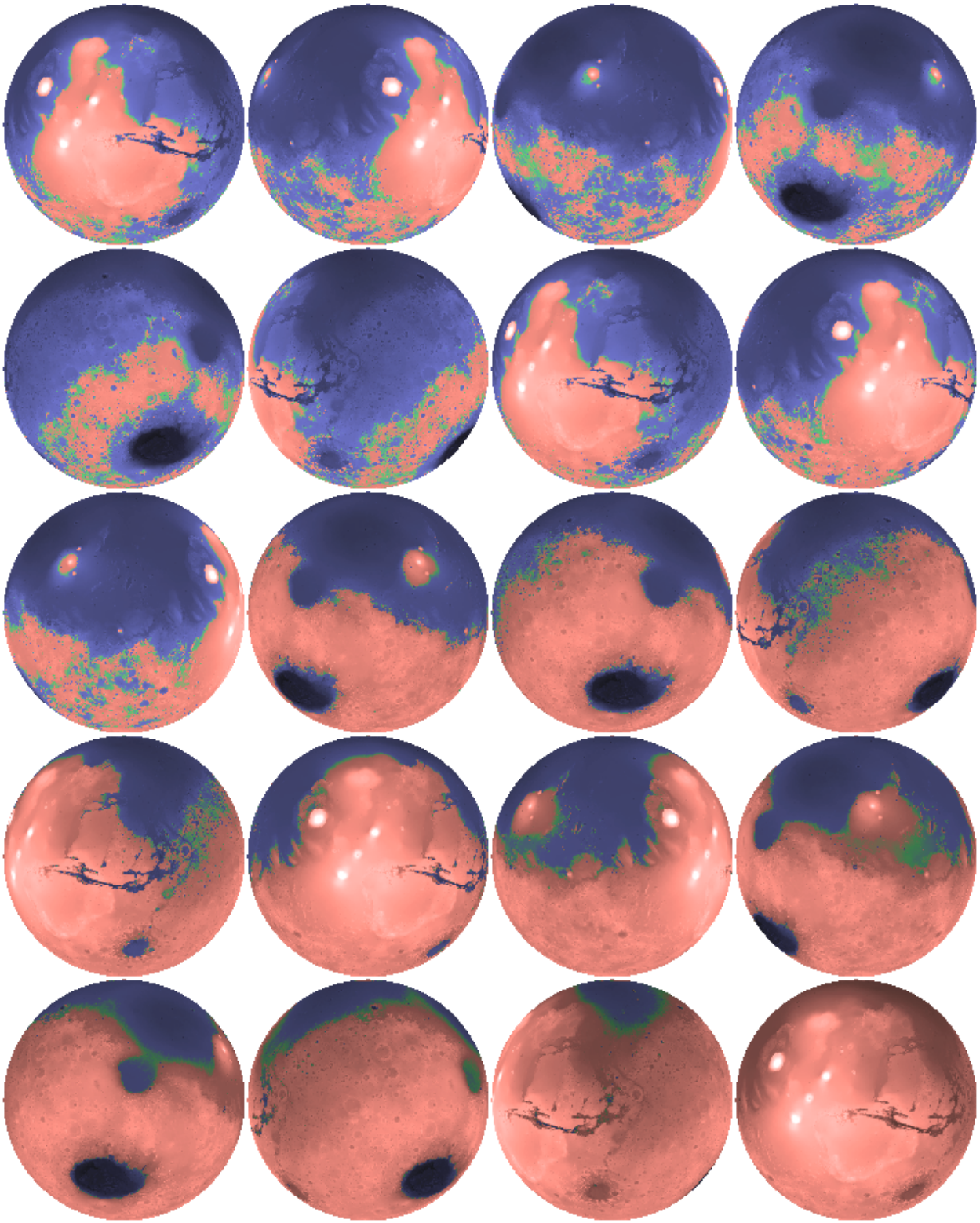

Figure 2: The computed level of the ocean for the time when 5% (9688 *m*), 10% (9688 *m*), 15% (9621 *m*), 20% (9554 *m*), 25% (9489 *m*), 30% (9422 *m*), 35% (9351*m*), 40% (9276 *m*), 45% (9141 *m*), 50% (6867 *m*), 55% (6569 *m*), 60% (6328 *m*), 65% (6157 *m*), 70% (5928 *m*), 75% (5660 *m*), 80% (5276 *m*), 85% (4742 *m*), 90% (4425 *m*), 95% (3901 *m*), and 100% (0 *m*) of craters was already created.

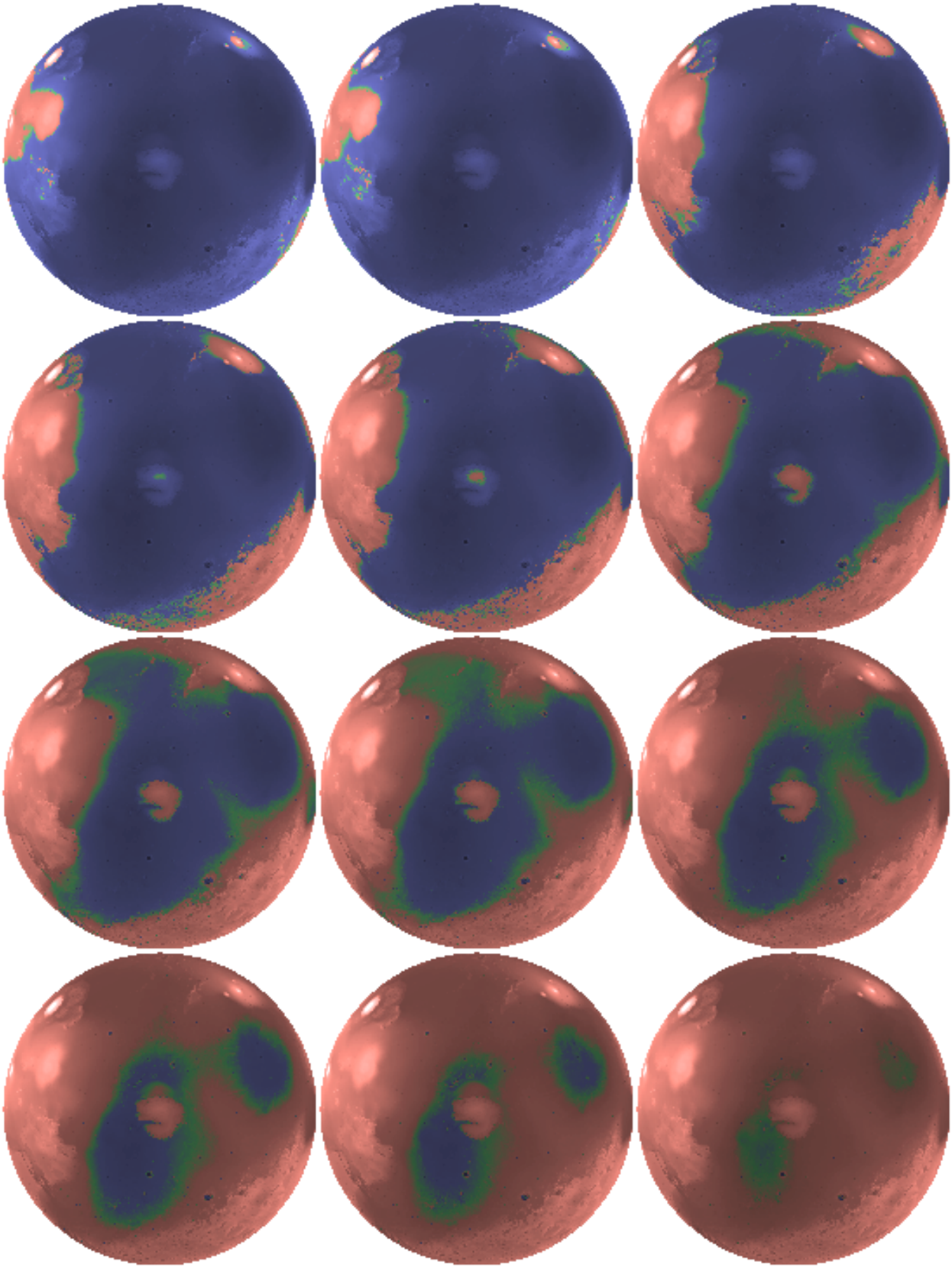

Figure 3: The computed level of the ocean for the time when 10% (9688 *m*), 30% (9422 *m*), 50% (6867 *m*), 65% (6157 *m*), 75% (5660 *m*), 85% (4742 *m*), 90% (4425 *m*), 93% (4201 *m*), 95% (3901 *m*), 96% (3728 *m*), 97% (3501 *m*), and 98% (3107 *m*) of craters was already created.