**TOPOGRAPHY PROFILE DIAGRAMS OF MARS: A STEP TOWARD 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:** After the initial proposal of Contact 1 and 2 [1], previously published papers about ocean on Mars can basically be divided in two groups. The first one was based on shorelines theory, however, shorelines were unfortunately not found in required amount. Papers from the second group, discussing basically whether Contact 1 or 2 is better approach, proposed as indicators for ocean on Mars: spiral beaches [2], sedimentation [3], hydraulic and thermal arguments [4], impact craters [5], fluvial valleys [6], tsunami generation and propagation [7], erosion features that might be ancient coastal terraces [8], etc. Recently, mathematical approach was proposed [9] providing a way to compute how deep Martian ocean was during each period of the planet history, including the probability that ocean did exist once. In Fig. 1 and Fig. 2 we have level of ocean for time when 65% and 85% of impact craters was already created [9], and in Fig. 3 Contact 1 and 2 [10]. It is interesting to find out that according to those proposed computations [9], as shown in Fig. 4, both Contacts are good approximations, each one for some particular period of the planet history. This also explains why shorelines were not found in supposed amount, ocean that is constantly drying up can not leave some significant shorelines at a particular level.

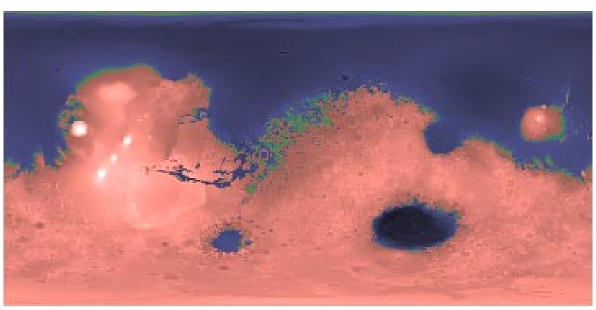

**Figure 1:** Ocean (6157 m) for time when 65% of impact craters was already created [9].

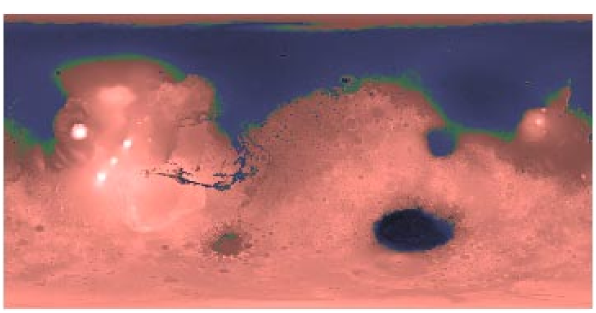

**Figure 2:** Ocean (4742 m) for time when 85% of impact craters was already created [9].

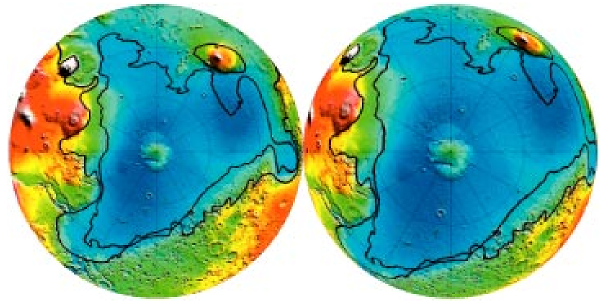

**Figure 3:** Lambert EqualArea (left) and Orthographic projection (right) of Contact 1 and Contact 2 [10].

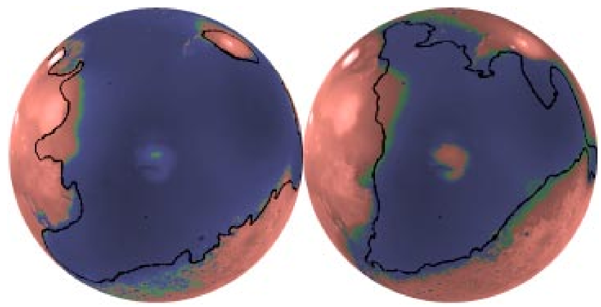

**Figure 4:** Comparison of Contact 1 and Contact 2 from Fig. 3 and level of ocean from Fig. 1 and Fig. 2.

However, while the proposed approach [9], based on mathematical theory of stochastic processes, is generally applicable to some classes of planets, it still needs to be formally proved that Mars is such planet too. One of the first steps in this way is representation of Martian topography and related values, in the form of *Topography Profile Diagrams* (*TPDs*).

**Input data:** MOLA 1/32° topography map was used as input data for computations, shown in Fig. 5. In the first case, 9496 craters ware marked using this image, while in the second case, 12548 craters was additionally marked using 1/64° MOC image. For computation and other tasks as well (finding impact craters), application named *Topolyzer* was developed.

**Topography Profile Diagrams:** All curves are normalized, so that we can read values of interest directly from the graph. They are shown in Fig. 6 and Fig. 7 for data-sets with 9496 and 22044 craters. Gray curves represent results for the topography of entire planet, and black curves represent results for the topography without regions marked in red in Fig. 5.

*Topography Profile Curve: TPC* (dash-dash) is a representation of the planet topography. It spans from *-8182m* to *21198m* in *y* direction, and like all other curves from *0%* to *100%* in *x* direction. By definition,

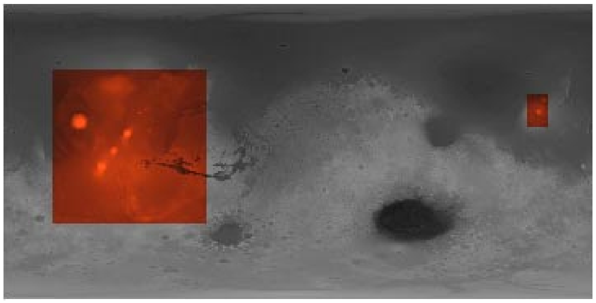

**Figure 5:** MOLA 1/32° topography map, simple rendering was used - darker is lower.

*TPC* has to satisfy requirement that if the point (*X*, *Y*) is on the curve, than *X%* of the planet is lower than *Y[m]*.

*Density of Craters Curve: DCC* (dot-dot) represents density of craters. Values in *y* direction are normalized according to the maximal one. Range from *0%* to *100%* in *x* direction is divided into 256 equal intervals. Each one corresponds to exactly one altitude range from *TPC*. Altitude of each impact crater corresponds then to the exactly one such range. Therefore, *Y* value of this curve is than the number of craters associated to the corresponding range.

*Filtered DCC: FDCC* (full-line) represents *DCC* filtered by a low-pass filter, included with the purpose of reducing the noise. Atomic step of shift filter (custom designed part of the filter) is defined as an operation of moving a crater from one range to another one. Quality of such shift filter is defined as the maximal distance between two such ranges used (lower is better), while each crater can be "moved" only once. Achieved performance is distance of only *3* and *4* for gray and black curves from Fig. 6, and distance of only *2* and *3* for corresponding curves from Fig. 7.

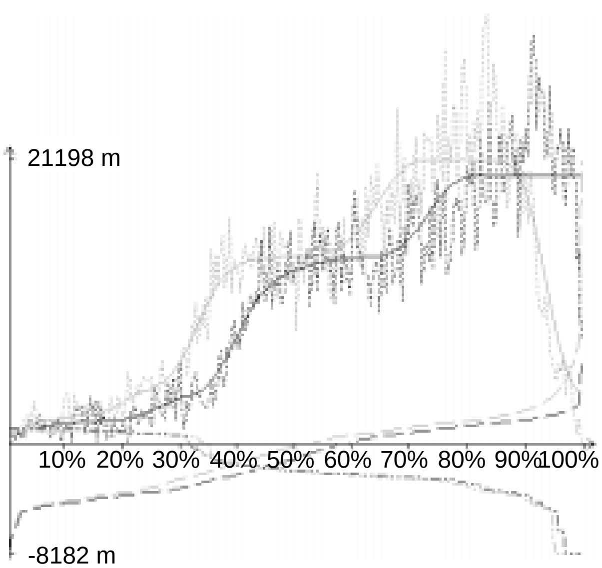


**Figure 6:** Topography profile diagrams for data-set with 9496 craters.

*Level-of-Substance-Over-Time Curve:* In *y* direction of *LSOTC* (dash-dot-dot) we have altitude of the surface, while in *x* direction time measured as percentage of impact craters already created at the particular time. By definition if the point ($X_1$, $Y_1$) is on this curve, then point ($X_2$, $Y_2$) must exist on *TPC* and point ($X_3$, $Y_3$) on *FDCC*, where $Y_1 = Y_2$, $X_2 = X_3$ and $X_1 + Y_3 = 100\%$ (starting point is defined when *FDCC* falls to *90%*).

**Results and implications:** Everything different than uniform distribution of density of craters must have some explanation. The easiest way to explain constantly decreasing part of the *FDCC* is to exclude from computations two regions marked in Fig. 5. The explanation is that those areas are geologically younger, because they contain largest volcanoes that were active in the past. On the other side, the *LSOTC* offers possible explanation of the constantly increasing part of the *FDCC* - that ocean was covering this part of the planet.

**Conclusion:** *TPDs* of Mars were presented, including explanation for constantly decreasing part of the *FDCC*. One possible way in which Martian ocean recession, timing and probability can be formally proved is to prove that nothing except the ocean could cause constantly increasing part of the *FDCC*.

**References:** [1] Parker T. J. et al. (1989) *Icarus, 82*, 111-145. [2] Pranzini E. and Zeoli A. (1999) *LPS XXX*, Abstract #1178. [3] De Hon R. A. (1999) *Int. Con. on Mars 5*, Abstract #6078. [4] Clifford S. M. and Parker T. J. (1999) *LPS XXX*, Abstract #1619. [5] Ormö J. and Muinonen P. (2000) *LPS XXXI*, Abstract #1266. [6] Gulick V. C. (2000) *LPS XXXI*, Abstract #2100. [7] Matsui T. et al (2001) *LPS XXXII*, Abstract #1716. [8] Parker T. J. et al (2002) *LPS XXXIII*, Abstract #2027. [9] Salamunićcar G. (2002) *COSPAR 34*, Abstract #01766. [10] Head J. W. et al. (1999) *Science, 286*, 2134-2137.

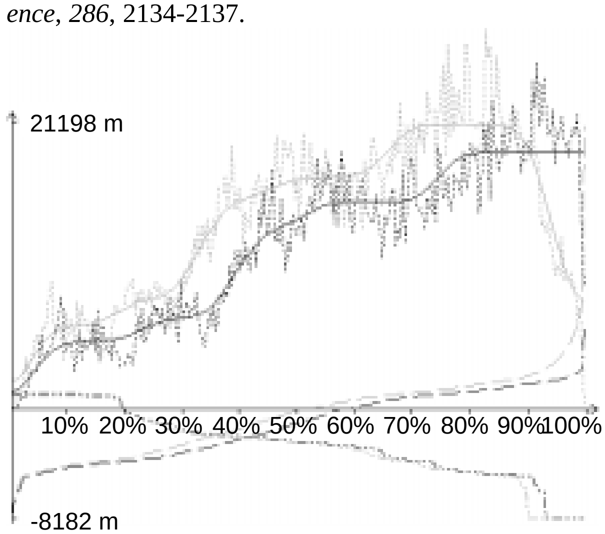


**Figure 7:** Topography profile diagrams for data-set with 22044 craters.