Distribution and occurrence of liquid water on Mars from the analysis of valley network structure.

A. Kereszturi, Collegium Budapest, Eotvos Lorand University of Sciences Department of Physical Geography, Hungarian Astronomical Association, e-mail: kru@mcse.hu

Introduction: The role of liquid water has been investigated on the Martian environment by several authors, but the origin of the channels and valleys on the surface is still controversial. Models suggest formation by precipitation, groundwater sapping, melting of surface ice by hot ejecta, or all together [1,2,3,4,5]. During the last years a complex image shaping regarding the occurrence and behavior of liquid water on Mars. One important aim in the near future is to connect in time and space the different water-related structures and processes.

Unfortunately we lack all the necessary knowledge for such synthesis, but there are several pieces of information on the areal and spatial ***distribution of water-related structures:***

- Selective nature of fluvial erosion [6], the inhomogeneous distribution of valleys.
- Discrete valleys show poorly graded sections, few tributaries, lack of smallest segments [7].
- Volcanic local and regional hydrothermal systems may have played a role in valley formation.
- Impact-driven local (in the crater) and regional (area of fallout) melting at craters larger than 20-30 km [8, 9] may have also been present.

The picture of the ***distribution of wet periods in time*** is also incomplete, but we have general views, the most important are the follows:

- Valleys are old, formed during the Noachian.
- Few valleys are Hesperian aged [10, 11].
- Based in OMEGA spectral measurements water and relative warm climate was on the planet only at the beginning (Phyllosian), later cold and wet acidic environment could be present only rarely on the surface (Theiikian) [12].
- Martian meteorites (aged between 4,56 Ga and 0,16 Gy) show only limited exposure to water, like few phillosilicates are in ALH84001 [13], few alteration minerals in Lafayette, Nakhla [14, 15].
- A northern ocean and crater lakes were present probably ephemerally for several time in Martian history [16].
- Recent gullies formed probably from brine seepage.
- Volcanic activity and related ice melting happened in the last 10-20 million years.

Drainage network analysis: on Earth the network shape of a drainage system can be used to reconstruct its origin, above all the source of the water [17]. The author has analyzed the Martian drainage networks based on morphology and morphometry from Viking, MGS (MOC), MEX (HRSC) images and MOLA topographic data [18]. The systems were classified into five groups based on appearance and physical dimensions together. The proposed main groups are the follows (with possible analogs from the Earth in brackets):

1. Weakly integrated, small, parallel valleys (centrifugal), 2. integrated small valleys (dendritic), 3. medium sized lonely valleys (disordered), 4. confined outflow valleys (catastrophic flood), 5. unconfined, braided outflow valleys (dichotomic). Strongly fractured network types are important because of the weak integration of valley systems. Most valleys show erosional structures, exceptions may be in the 5. group of braided patterned outflow systems. Some examples are visible in the Figure, where rows from top to bottom represents examples for the five types form 1 to 5.

Conslusion: It seems to be possible that with the analysis of valleys' network structure to get closer to the origin of water produced them. During the next years these and other data on the presence of liquid water on past Mars may be synthesized into one common picture. The possible environment of water-related mineral alterations inside the Martian meteorites may be positioned into this picture. We may get data about the time of their formation (position in planetary evolutionary history of liquid water), just like information on their spatial distribution (spatial position according to surface and subsurface environment types). Such results help reconstruct the environmental conditions on Mars were present during the formation water-related minerals in Martian meteorites.

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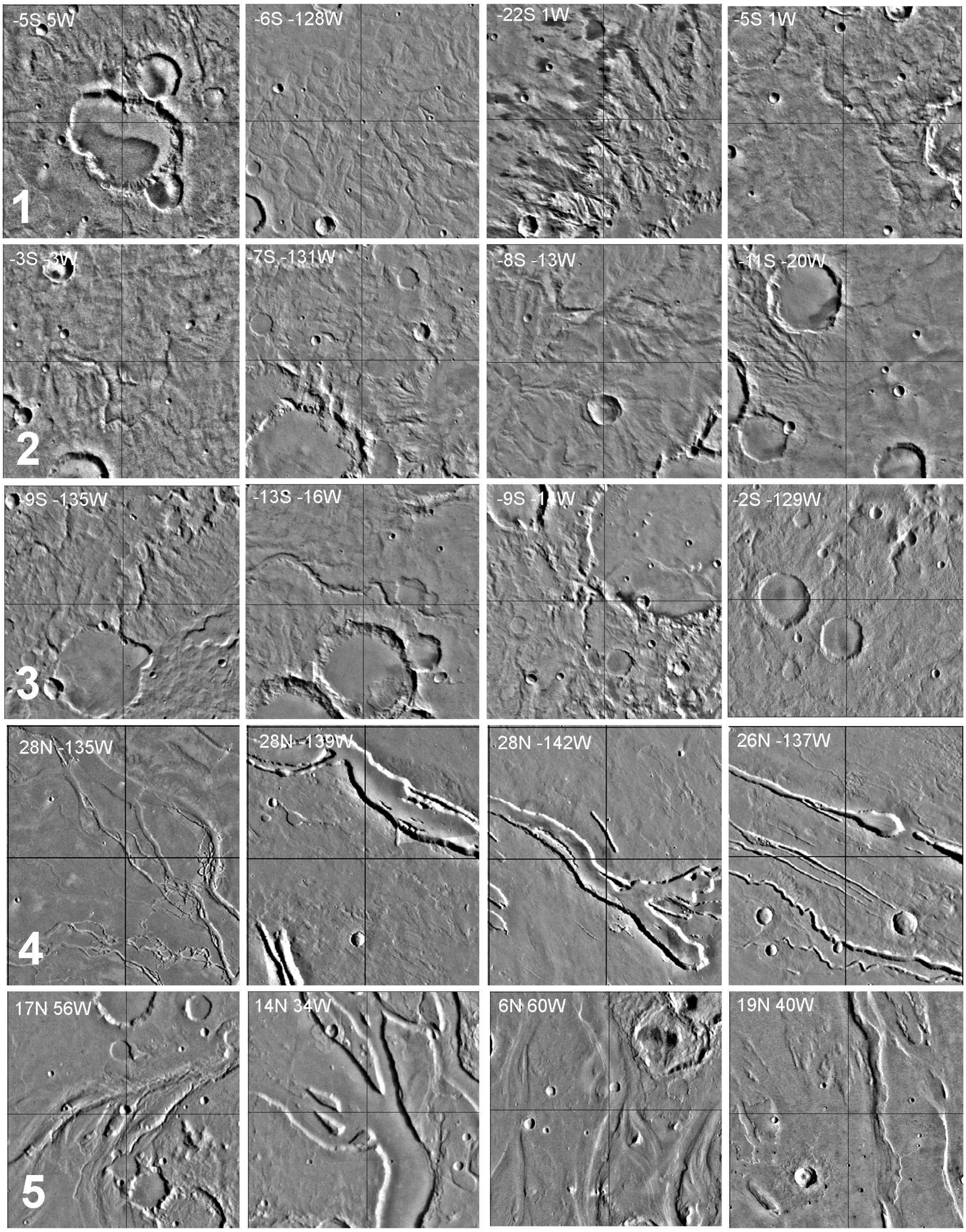

Figure: Examples for the 5 proposed valley network system types. Each row represent one type, the images are from the Viking Orbiter mosaic map and show 2x2 degree areas in mercator projection