Discrete Episodes of the Valley Network Formations in Locras and Cusus Valles on Mars

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Among various geological features suggesting the existence of water on the martian surface, valley networks represent the best evidence that liquid water once stable in the martian environment. For this reason, valley networks are important indicators of the palaeoclimate of Mars. Although decades of investigations have been performed, many questions remain in their origins and formational histories. There are generally two hypotheses regarding their formations, such as groundwater sapping and surface runoff following rainfall. Because most of the previous studies except for Viking-based observations are based on topographic data, which have relatively low resolutions than visible of infrared images, smaller-scale features related to valley networks remain unstudied. Therefore, in this study, we utilize recently-acquired high-resolution images to carefully map valley networks to constrain their formational histories to help understand their impact on the martian surface environment.

In order to perform a global-scale detailed mapping of the valley-network system, we selected Locras Valles and Cusus Valles as the study area of this work, because these areas are dissected by numerous valley networks and thus useful to establish the methodology for global mapping of valley networks. Also, we carefully observe the geomorphologic characteristics of the valley networks as well as calculate their physical characteristics, such as the fractal dimension, the residence time, and the drainage density, to constrain their formations.

Our preliminary results include; (1) The network-systems of the study area are generally similar to the terrestrial fluvial network-systems based both on their geomorphologic characteristics and on their fractal dimensions; (2) The outlets of the valleys seem to be disturbed by the putative seashores of palaeoseas; (3) Positive correlations between the drainage densities and the mean slopes exist; (4) The depths of valleys are probably much deeper than fluvial valleys that might be formed only by rainfall, which comes from the disagreement between the observed valley depths and the residence time; (5) Large craters are generally found at upstream parts of the valley networks; and (6) Small-scale valley networks exist within small craters in some palaeolakes. We interpret (1)-(3) as evidence that the network-patterns are results of rainfall, and (4)-(6) as that the valleys have been eroded by sudden flows from craters.

These likely indicate that rainfall have formed immature valley networks of the study area before subsequent and sudden outflows from craters eroded these valleys deeply, although it is difficult to identify what causes the outflow from craters. Potential scenarios may include hydrothermally-triggered outflows to explain the sudden occurrence of them.