Examination of Origins of Lobate Landforms with Gullies on Mars from an Inverse Analysis of Debris-flow Deposits

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Gullies and lobate deposits that commonly occur on the flanks of craters and dune foresets on Mars are often interpreted to have been formed by debris-flow processes. Debris-flow processes suggest the existence of liquid water on the surface of Mars, which is believed to have an extremely cold and dry environment. Debris flows occur when masses of poorly sorted sediment, agitated and saturated with water, surge down slopes in response to gravitational attraction. Thus, recent activities of debris flows imply the existence of liquid water phase materials on the Martian surface. However, the dry granular flow caused by a slope avalanche can also form gullies and lobate deposits, which resemble debris-flow deposits, so that there are still uncertainties over the occurrence and origins of liquid water on the modern Martian surface. This study proposes a method for estimating debris-flow properties, in order to distinguish debris-flow processes on Mars. In this method, one-phase bingham fluid model is employed here as the forward model, and flow parameters such as yield strength and flow viscosity required for the forward model are optimized to reconstruct geomorphological features of Martian lobate deposits. Genetic algorithm is used for this parametric optimization. Results of the inverse analysis suggested that a lobate deposit on Mars can be formed by a debris flow that shows flow properties similar to water-saturated debris flows on the Earth. If rheological parameters of the flows can be determined from the surface morphology of lobate deposits, it would be helpful for distinguishing debris-flow processes from dry-granular flows. The inverse analysis method proposed here with future field surveys and experimental studies will provide quantitative criteria for identifying debris flows from geomorphological features of lobate deposits.

Keywords: Martian debris flow, Martian liquid water, Bingham plastic model