The Giant Sinkholes of Mars: Furthering our Understanding of the Red Planet’ s Hydrosphere

*Alexis Palmero Rodriguez[1], Hideaki Miyamoto[2], Victor Baker[3]

1. Planetary Science Institute, 2. University of Tokyo, 3. University of Arizona

One of the greatest puzzles in the exploration of our Solar System is the history of water on Mars. There is mounting evidence gathered over 50 years of research indicating that early in its history, oceans repeatedly formed on Mars, first in the presence of a globally interconnected hydrosphere and hundreds of millions of years later in connection to the massive disruption of vast aquifers.

Evidence of the aquifers includes the presence of chaotic terrains (zones of collapse) that are associated with catastrophic flood channels. The nature of the aquifers remains a mystery. Some researchers suggest that they might form part of a global hydrosphere confined beneath kilometers of permafrost. This hypothesis suggests that southern circum-Chryse may have had a crust exceeding abundant in volatiles. However, there is another view- that the terrain disruptions that we observe are zones where subterranean rivers transported groundwater from distal regions. The location of the aquifers that fed into the proposed underground rivers remains uncertain, though some workers have suggested the subsurface of the Tharsis volcanic rise as a likely source location. If this hypothesis is correct, subterranean river flow was a key component of Mars hydrology, which we are just beginning to understand.

The former presence of subterranean rivers has been inferred from the mapping of subsidence patterns in highland regions that adjoin large outflow channel systems. These studies suggest that the rivers flowed through immense conduits with diameters of ~10 km and perhaps larger. These features have no terrestrial analogs and hence might reflect some unique conditions that developed on Mars.

Here, we further test this hypothesis and refine its implications towards our understanding of the planet’ s early geologic history. We present the first identification of potential sinkholes that occur within and near the proposed region of subsidence. We used the sinkholes diameters, and their floor depths are proxies to the conduit dimensions and their distribution within the Martian upper crust. Our preliminary results confirm the gigantic nature of the conduits and appear to position their distribution at discrete elevation ranges that connect tectonic trends and unconformities that we are tracing throughout the study areas. The results outline and constrain the locations of the potential aquifers to a few areas of the Martian western hemisphere at sufficient elevations to generate the hydraulic head required to produce the subsurface flows. In this respect, we identified an unconformity in the highlands that might trace an area of collapse created when the source aquifers were drained. The area, we find, was subsequently buried by lavas.

Our results depict Mars’ early hydrosphere as an extremely dynamic planetary feature and highlight the role of subterranean river flow as a substitute to surface water drainage as an essential modifier to the planet’ s ancient landscapes.

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