Large impact basin-related climatic and surface effects on Mars: Argyre basin as a case study

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The collision of large bolides with planets with substantial atmospheres, such as Earth and early Mars, results in significant climatic and surface effects. For very large impacts, forming basins \( \approx 500 \) km in diameter, these post-impact effects would be global and include [1]: (1) transient high atmospheric and surface temperatures, (2) deposition of material that was vaporized by the impact event and subsequently condensed (e.g. terrestrial spherule layers), (3) a transient, vigorous hydrologic cycle characterized by rainfall rates sufficient to produce flooding, and (4) surface aqueous alteration, made possible by the hot rainfall and high temperatures. On Mars, the formation of such large basins, including Hellas, Isidis, and Argyre, occurred in the early- to mid-Noachian [2]; while younger, smaller basins would have influenced the climate and surface on a local or regional scale, such intense, global effects would have occurred only during the earliest parts of Mars history. Previous work has qualitatively [1] and quantitatively [in 3D; 3,4] constrained the effects from large basin-scale impacts on Mars, but lacks detailed application to any specific impact.

The fact that these drastic, global effects would occur following each large basin-scale impact [1,3,4] implies that the effects from formation of the youngest of the large basins would be best preserved and closest to the present-day surface. Here, we build upon previous work [1,3,4] by qualitatively and quantitatively exploring the climatic and surface effects from the formation of the youngest large basin, Argyre. We find that: (1) a tens of meters thick, near-globally-distributed, olivine and glass-rich spherule layer should be preserved on or very near the surface, (2) the induced hydrologic cycle would have been characterized by rainfall rates akin to Earth rainforests and would have lasted for decades to centuries, (3) the intense rainfall would have caused flooding, significant erosion, and smoothing of landforms, and (4) hot rainfall and high temperatures would have caused surface aqueous alteration, including partial alteration of the olivine-rich layer to carbonates as well as alteration of basaltic material to Fe/Mg-smectites and Al-phyllosilicates, which would present in a leaching profile.

Implications of these findings include: (1) distinguishing the role of impact-induced aqueous alteration from that associated with normal climate conditions, (2) predictions of areas where the spherule layer and alteration products may be observed, (3) the transition from a basin-scale impact-dominated regime to a basin-free regime in martian climate evolution, and (4) guidelines
for exploration and recognition of these impact-related units at rover and sample return scale.

**References**


