CASCADING LAKES, SPILLWAYS, AND SUBAQUEOUS DEBRIS FLOWS: MODELS FOR MARTIAN PALEOLAKES.

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> *"Certainly, in the future as increased aerial photographic coverage of our celestial neighbors becomes available, the search for, and recognition and study of, ancient lakes, their features and basins, will be of great importance to our space effort in interpretation of past or present celestial environments and in selection of landing sites."*
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> C.C. Reeves, Jr., 1968,
> Introduction to Paleolimnology

Introduction

Newly acquired MOLA profiles [1,2], over the northern lowland plains region of Mars, indicate that the regional flatness (< 1° slopes) and low surface roughness (< 2m over 100 km baseline rms variation) is consistent with large-scale terrestrial depositional environments such as fluviolacustrine basins and the oceanic abyssal plains. However, the origin of the flatness of the northern hemisphere is unknown. Current explanations to account for both the extraordinary flatness and smoothness of the northern plains calls for the formation of vast lakes [3,4,5,6,7,8] or oceans [9,10,11]. Recent MOLA results [12] supply additional evidence to corroborate these earlier geomorphic studies which indicated that large standing bodies of water occupied the northern plains of the planet.

Cascading Lakes and Spillway Systems

Earth:

The recent deglaciation of Eurasia and North America provide us with "Martian-Scale" analogs to extensive catastrophic flood regimes and outwash plains; lacustrine basins, and interbasin spillways. These large glacial lakes which received flood discharges have huge channels at their inlets and outlets but lack such channels across their bottoms [*13*]. Additionally, the arrival of floodwaters from topographically higher lakes to downstream lakes triggers a domino-like sequence of lake drainage floods [*14*]. The enormous volume of flood water exceeded the capacity of the basins, which caused spillover and downcutting at outlet areas, until the upstream lakes drained. The end result would be massive ponding in the terminal, lowest most topographic basin(s).

The largest cascading lake and spillway system is the Trans-Siberian drainage complex. This system extended from the Chersky Mts. of Siberia in the east to the Alps in the west, and drained a catchment area equaling 2.3×10^7 km^2 [15]. This is an area 3 times the size of the Amazon basin. This system is comprised of the Black, Caspian, and Aral Seas as well as several lakes. The total areal coverage of these bodies of water exceeded 3×10^6 km^2. This flood waters focused first in the Black Sea and then marched west via the Sea of Marmosa to finally ended up in the Mediterranean Sea and Atlantic Ocean [15].

Mars:

Scott et al., [3] identified 15 large topographic depressions, each having closures exceeding 100,000 km^2 in areal extent and depths of 1000 m or more; these basins were considered prospective sites for paleolakes. Elysium, Amazonis, Utopia, Isidis, and Chryse along with their possible interconnections or spillways are the five basins that contain the best evidence of standing bodies of water. These basins drain an estimated total area .of 4.8×10^7 km^2. The total areal coverage of these bodies of water is estimated to be 7×10^6 km^2. Individual lake basins on Mars (Chryse, Utopia, Isidis, Amazonis, and Elysium) were either / both the precursors to the northern polar ocean or last vestiges of the ocean as it dried up. The cascading lake scenario could have initially provided the flood water impetus to form the northern ocean.

The Chryse basin clearly exhibits huge inlet channels, outlet channels and lacks any incised channels across its floor. Maja Valles flows in from the southwest, Kasei Valles from northwest, Shalbatana and Simud Vallis from south, Tiu and Ares Vallis from the southeast, and Mawrth Vallis from the northeast. These morphologic associations are observed in large terrestrial lake basins which receive enormous flood discharges and eventually cascade or spill over into another basin [*13*]. The Chryse basin floor contains an area of undissected terrain with wrinkle ridges (2.75×10^3 km^2). These wrinkle ridges appear subdued and mantled in places perhaps due to ponding and burial by flood sediments. Indications of ponding and subsequent outflow are also observed in the northeast of Chryse Planitia (30°N; 41°W), where streamlined islands are oriented to flow from Maja Valles, some 950 km away.

Subaqueous debris flows

Earth:

Daly [16] was the first to suggest the idea of turbidity currents as a geologic agent. He proposed that these sediment laden currents were responsible for the origin of submarine canyons. The first paper to accurately describe an actual subaqueous debris flow, turbidity current and submarine slump was based on the 1929 Grand Banks earthquake [17]. This earthquake shook the continental slope south of Newfoundland and resulted in the destruction of all the submarine telegraph cables lying downslope of the epicentral area. Heezen and Ewing [17] explained the successive downslope cable obliteration by means of a subaqueous debris flow which transitioned into a turbidity current. This sediment flow then rumbled down the continental slope and eventually settled out onto the abyssal plains, 750 km from the continental slope. Heezen, et al. [18] determined that the flat floors of the oceanic abyssal plains are due to the ponding of sediments derived from turbidity currents. The oceanic abyssal plains are the flattest surfaces on Earth.

Subaqueous debris flows can travel over slopes as low as 0.1° and a distance of 1,600 km [19]. In the Canary Basin, subaqueous debris flow deposits cover an area of 30,000 km^2 . Similar deposits have also been observed on the Amazon cone, North American continental rise, Gulf of Mexico, and Mediterranean Sea. Subaqueous debris flows are a much more important depositional process on the sea floor than previously suspected. For example, subaqueous debris flows generally develop into turbidity currents.

Mars:

Recent work by Tanaka [20, 21] proposes that subaerial debris flows formed the Hesperian smooth plains Simud/Tiu deposits. [20, 21] geologically mapped the whole southeast region of Chryse Planitia and studied the regional morphology. Subaerial debris flows were the primary mechanism that Tanaka [20, 21] investigated, he gave the subaqueous debris flow hypothesis only a cursory mention.

We propose that the deposits located near the mouths of outflow channels in the northern plains are subaqueous debris flows that were emplaced in standing bodies of water that collected when the outflow channels debouched into these basins. We will discuss the morphology of terrestrial subaqueous debris flows and compare this to what we observe on Mars.

References

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