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# An analysis of open-basin lake deposits on Mars: Evidence for the nature of associated lacustrine deposits and post-lacustrine modification processes

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ABSTRACT

A large number of candidate open-basin lakes (low-lying regions with both inlet valleys and an outlet valley) have been identified and mapped on Mars and are fed by valley network systems that were active near the Noachian–Hesperian boundary. The nature of processes that modified the open-basin lake interiors subsequent to lacustrine activity, and how frequently sedimentary deposits related to lacustrine activity remain exposed, has not been extensively examined. An analysis of 226 open-basin lakes was undertaken to identify evidence for: (1) exposed deposits of possible lacustrine origin and (2) post-lacustrine-activity processes that may have modified or resurfaced open-basin lakes. Spectroscopic data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) instrument were analyzed over identified exposed open-basin lake deposits to assess the mineralogy of these deposits. Particular attention was paid to the possible detection of any component of aqueous alteration minerals (e.g. phyllosilicates, hydrated silica, zeolites) or evaporites (e.g. carbonates, sulfates, chlorides) associated with these exposed deposits. The aim of this paper is to act as a broad survey and cataloguing of the types of lacustrine and post-lacustrine deposits that are present within these 226 paleolake basins. Results of the morphologic classification indicate that 79 open-basin lakes (~35% of the population) contain exposed deposits of possible lacustrine origin, identified on the basis of fan/delta deposits, layered deposits and/or exposed floor material of apparent lacustrine origin. Additionally, all 226 open-basin lakes examined appear to have been at least partially resurfaced subsequent to their formation by several processes, including volcanism, glacial and periglacial activity, impact cratering and aeolian activity. Results from the analysis of CRISM data show that only 10 (~29% of the 34 deposits with CRISM coverage) of the exposed open-basin lake deposits contain positively identified aqueous alteration minerals, with one deposit also containing evaporites. The identified hydrated and evaporite minerals include Fe/Mg-smectite, kaolinite, hydrated silica and carbonate, with Fe/Mg-smectite the most commonly identified mineral. These results indicate that hydrated and evaporite minerals are not as commonly associated with lacustrine deposits on Mars as they are on Earth. This suggests *in situ* alteration and mineral precipitation, a common source of such minerals in terrestrial lakes, was not a major process occurring in these paleolacustrine systems, and that the observed minerals are likely to be present as transported material within the lacustrine deposits. The lack of widespread *in situ* alteration also suggests that either the water chemistry in these paleolake systems was not conducive to aqueous alteration and mineral precipitation, or that the open-basin lake systems were relatively short-lived.



## 1. Introduction

Candidate paleolake basins have long been observed on Mars (e.g. Goldspiel and Squyres, 1991; De Hon, 1992; Forsythe and Zimbelman, 1995; Cabrol and Grin, 1999, 2001) based on their distinct morphology. Since their initial discovery, several workers have compiled extensive and thorough catalogues of these features (e.g. De Hon, 1992; Cabrol and Grin, 1999, 2001; Fassett and Head, 2008a), dividing martian paleolakes into two major categories: closed-basin lakes and open-basin lakes (Cabrol and Grin, 1999; Fassett and Head, 2008a). Closed-basin lakes have inlet valleys but lack outlets, and they are inferred to be paleolakes due to the observed morphology of the surrounding terrain (i.e. inlet valleys) and associated deposits (Cabrol and Grin, 1999). Open-basin lakes have both observed inlet valleys and an outlet valley (Cabrol and Grin, 1999; Fassett and Head, 2008a). The presence of both inlet valleys and an outlet valley means that water within the basin must have ponded to approximately the level of the surface adjacent to the outlet valley head before breaching and overflowing

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