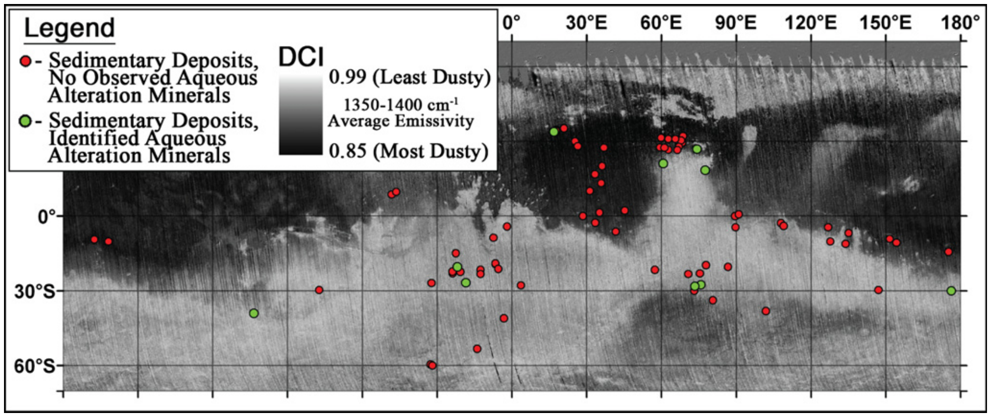

Fig. 11. Global distribution of exposed open-basin lake deposits compared with such deposits containing identified aqueous alteration minerals. Background is global dust cover index (DCI) (Ruff and Christensen, 2002) overlain on MOLA hillshade topography (Smith et al., 2001).

on Earth, where evaporites and aqueous alteration minerals are commonly produced *in situ* (Brunskill, 1969; Eugster and Hardie, 1975, 1978; Jones and Bowser, 1978; Kelts and Hsu, 1978; Strong and Eadie, 1978; Blatt et al., 1980; Jones, 1986; Hay et al., 1991; Hillier, 1993; Wetzel, 2001), which suggests differing conditions on Mars that were not conducive to *in situ* alteration and mineral precipitation. Two possible explanations for the lack of *in situ* alteration and mineral precipitation are: (1) a water chemistry that was not conducive to aqueous alteration of transported sediment and the precipitation of carbonates and/or (2) a geologically short-lived period of lacustrine activity within the open-basin lake systems. A geologically short period of lacustrine activity is also supported by the lack of chlorides and sulfates within these open-basin lake deposits, both of which have been identified on the surface of Mars (e.g. Gendrin et al., 2005; Osterloo et al., 2008, 2010; Bishop et al., 2009; Glotch et al., 2010). These evaporites are typically the last to develop within a lacustrine system, as the basin becomes less dominated by surficial flows and more playa-like as it is filled in with sediment (Eugster and Hardie, 1975, 1978; Jones and Bowser, 1978; Kelts and Hsu, 1978; Wetzel, 2001). The observation that chlorides and sulfates are not commonly observed in martian open-basin lakes suggests that the lacustrine systems were not active long enough to become infilled and begin precipitating these evaporites. The short-lived nature of many martian paleolake systems has been proposed previously based on observed morphologies (e.g. Howard et al., 2005; Irwin et al., 2005), and is supported by the findings of the work presented here; however, ruling out an unsuitable water chemistry is not possible with the data presented here.

6. Conclusions

Based on a detailed morphologic analysis of 226 open-basin lakes, approximately one-third (~35%) of these paleolakes contain exposed sedimentary deposits of possible lacustrine origin; however, all of the open-basin lakes are at least partially resurfaced, with volcanic resurfacing the most abundant resurfacing process identified. These findings support earlier, less detailed observations that post-lacustrine resurfacing has extensively modified the open-basin lake record on Mars (Fassett and Head, 2008a). Based on the geographic distribution of volcanically resurfaced open-basin lakes, many appear to have local volcanic sources (e.g. Syrtis Major, Hesperia Planum), while some do not and require more distributed sources of volcanic resurfacing such as dikes. This analysis also revealed a noticeable cluster of open-basin lakes with exposed sedimentary deposits in Nili Fossae. This suggests either exhumation or more significant lacustrine activity in this area, with an episode of exhumation being the preferred explanation. Furthermore, the distribution of glacially resurfaced open-basin lakes is consistent with both the latitude dependence of this class of ice-related deposits (e.g. Head et al., 2003, 2010; Milliken et al., 2003; Levy et al., 2010), as well as periods of Late Amazonian glaciation (e.g. Mustard et al., 2001; Head et al., 2003, 2008; Schon et al., 2009; Dickson et al., 2010, 2011).

Based on a survey of targeted CRISM observations over exposed open-basin lake deposits, we have observed that the number of these deposits containing spectrally identified aqueous alteration and evaporite minerals is small (10) compared with the overall number of deposits with CRISM coverage (34). This is a divergence from the common mineralogies observed in terrestrial lacustrine deposits (Jones and Bowser, 1978; Blatt et al., 1980; Leeder, 1999; Wetzel, 2001), and could be due to a spectrally obscuring unit, a lack of spectral coverage at adequate resolution or an unaltered, detrital composition of the sedimentary deposits; however, it appears that neither a spectrally obscuring unit or a lack of data coverage can be the sole cause of this disparity. Based on our observations, we draw the following conclusions:

1. *In situ* aqueous alteration and mineral precipitation was not a dominant process within the majority of open-basin lake systems.
2. The observed aqueous alteration minerals and carbonate in exposed open-basin lake deposits are present as transported material.
3. These materials are reflective of the composition of the bedrock in their watershed.

These conclusions are consistent with the findings of previous workers that suggest aqueous alteration and evaporite minerals identified in individual open-basin lake deposits are present as transported material as opposed to having formed *in situ* (e.g. Ehlmann et al., 2008a, 2008b; Dehouck et al., 2010; Ansan et al., 2011). The lack of evidence for *in situ* alteration and mineral precipitation can be explained by either a water chemistry that was not conducive to such processes, or a short-lived period of lacustrine activity for most open-basin lakes. Determining which of these two hypotheses better explains the observations presented here is very important, as both of these scenarios have strong implications for the climate and hydrologic cycle of Mars during this early period of lacustrine activity.

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