WHAT LURKS IN THE MARTIAN ROCKS AND SOIL? INVESTIGATIONS OF SULFATES, PHOSPHATES, AND PERCHLORATES
Sulfate-bearing deposits at Dalangtan Playa and their implication for the formation and preservation of martian salts†

W.G. KONG¹,*, M.P. ZHENG¹, F.J. KONG¹ AND W.X. CHEN¹

¹MLR Key Laboratory of Saline Lake Resources and Environments, Institute of Mineral Resources, CAGS, Beijing 100037, China

ABSTRACT

The sulfate-bearing strata on Mars must have recorded rich information of its aqueous history. However, the hydrated sulfates observed in the surface thin layer by remote sensing, especially widespread kieserite, are likely weathering products rather than pristine deposits. Here we report the results from mineralogical investigations and environmental monitoring on the sulfate-bearing Dalangtan Playa (an analog site with Mars-like environmental conditions in northern Tibetan Plateau) to examine the depositional and secondary processes of hydrated sulfates. The regional deposition characters of DLT Playa were described based on our mineralogical results. Widespread kieserite was identified in situ by portable laser Raman spectrometer on the weathered surface of the Mg-sulfates-rich section, which formed from the hexahydrate dehydration after exposed to the ambient conditions in six months covering the summer, and survived in the winter. During summer days, wind and sunlight may have facilitated the dehydration process, leading the formation of kieserite from dehydration. On the basis of the observed kieserite formation, the recorded local environment conditions, as well as previously reported phase diagrams for Mg-sulfates, we suggest that the current diurnal relative humidity-temperature circles at low latitudes of Mars favor the formation of kieserite through secondary processes.

Keywords: Mars analogs, Tibetan Plateau, DLT Playa, sulfates deposits, martian kieserite

INTRODUCTION

Various minerals closely related to the aqueous history of Mars have been identified or indicated, including clays (e.g., Bishop et al. 2008; Carter et al. 2010; Ehlmann et al. 2009; Glocott et al. 2006; Mustard et al. 2008; Wang et al. 2006a), carbonates (e.g., Bishop et al. 2013; Boynton et al. 2009; Carter and Poulet 2012; Ehlmann et al. 2008; Michalski and Niles 2010; Morris et al. 2010), sulfates (e.g., Arvidson et al. 2005; Gendrin et al. 2005; Kounaves et al. 2010; Langevin et al. 2005; Lichtenberg et al. 2010; Murchie et al. 2009; Squyres et al. 2006; Wang et al. 2006b), and chlorides (Bishop et al. 2013; Glocott et al. 2010; Jensen and Glocott 2011; Murchie et al. 2009a; Osterloo et al. 2008, 2010; Ruesch et al. 2012; Wray et al. 2009). It is reasonable to get information on the aqueous history of Mars from the detailed study of these minerals. Abundant calcium sulfates, mostly gypsum occur near the north polar region of Mars (Langevin et al. 2005). Mg-sulfates have the largest quantities and widest distribution at low latitudes of Mars. For example, those discovered by Observatoire pour la Minéralogie, l’Eau, les Glaces et l’Activité (OMEGA) fill most part of Valleys Marineris and nearby lowlands (Gendrin et al. 2005). Stratigraphic relations of sulfates with different hydration degrees (poly- and monohydrated sulfates) were reported on the basis of comprehensive orbital data sets (Mangold et al. 2008), and clarified for the Martian light-tone layered deposits (ILD) at various sites combining the high-resolution Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) with the Context Camera (CTX) data sets (e.g., Bishop et al. 2009; Flahaut et al. 2010; Lichtenberg et al. 2010; Milliken et al. 2010; Murchie et al. 2009a, 2009b; Roach et al. 2009, 2010; Wiseman et al. 2010), and kieserite (monohydrated Mg-sulfate) was specified to be widespread at low latitudes (e.g., Arvidson et al. 2005; Bishop et al. 2009; Gendrin et al. 2005; Mangold et al. 2008; Roach et al. 2009).

The hydration states of sulfates are strongly influenced by the relative humidity (RH) and temperature (T) of ambient environments. Thus the hydrated sulfates on the martian surface might be the products from the weathering of primary deposits under Mars atmosphere. Many studies through laboratory experiments or thermodynamic modeling have been carried out to investigate the stability properties under different RH and T conditions for sulfates (e.g., Chipera and Vaniman 2007; Chou and Seal 2003, 2007; Grevel et al. 2012; Kong et al. 2011; Steiger et al. 2011; Vaniman et al. 2004, 2006; Wang et al. 2009, 2011; Xu and Parise 2012), as well as for sulfates associated with smectites under Mars-like RH and T conditions (Wilson and Bish 2012). These studies have provided critical information for discussing how these observed hydrated sulfates originate.

In nature, complex factors might be involved to constrain the occurrence of specific sulfate species, thus studies on terrestrial analog sites with similar mineralogy and environmental conditions are needed to help linking these fundamental studies with Mars observations.

Terrestrial analog studies have focused on various aspects and