

Stages of Development and Growth of Salt Polygonal Surface Structures in Qaidam Basin, Western China, and Their Counterparts on Mars. Y.N. Dang¹, L. Xiao^{1,2}, Y. Xu¹, F. Zhang¹ 1. State Key Laboratory of Lunar and Planetary Sciences, Macau University of Science and Technology, Taipa, Macau (yanan_gis@163.com), 2. Planetary Science Institute, China University of Geosciences, Wuhan, 430074, P. R. China.

Introduction: In natural salt playa or in evaporation pools for the salt extraction industry, one can sometimes observe surprisingly regular structures formed by ridges of salt [1]. These ridges (uplifted borders) connect to form a self-organized network of polygons few centimeters to tens of meters in diameter, which here we call Polygonal Surface Structures (PSSs). They are usually caused by desiccation cracking and/or lateral growth of salt crystals within the stratified salt layers [2, 3]. The sequence of processes responsible for PSS formation in terms of abundance and morphology is difficult to establish and as a result, their growth mechanism may be misinterpreted.

Raised rim salt polygons that are morphologically similar to those on Earth were recently reported to occur on Mars by [4]. In this work, we aim to clarify a sequence of processes involved in the formation of morphologically diverse PSSs within playas in Qaidam basin, a hyperarid inland basin located on the NE corner of the Qinghai-Tibet plateau of China. A very arid climate and a long-term, general drying trend of the basin have caused the basin lake system to shrink and to be turned into salt lakes, some of which finally ended up in salt-encrusted playas [5-9]. Numerous PSSs of diverse morphologies are investigated to shed light on their formation-related processes and enhance our understanding of their formation mechanism, possibly analogous to their counterparts on Mars settings [4].

Data and Methods: High-resolution Google Earth and ultra-high resolution Unmanned Aerial Vehicle (UAV) images are used to investigate the spatial distribution and the surface morphology of PSS landforms, aided by close-up photos taken during fieldwork surveys carried out over the summers from 2014 to 2018. A set of DEMs (Digital Elevation Models) derived from a series of UAV images was selected to display detailed topographic and morphologic characteristics of PSSs. Martian PSSs investigated in this study were characterized using the High Resolution Imaging Science Equipment (HiRISE) data set [10].

Observations and Results: *Initial stage of PSS evolution.* Type 1: A polygon is initiated by doming effect at points of weakness, followed by crustal fracture extension and connection (Figs. 1a and b). From these domes two or three anticlinal folds may grow radially at about 120 degrees. With extension of cracks in which the growth of salt crystals (driven by capillary upflow due to evaporation) continues, the domes are extended along the linear fractures to form fin- or is-

land-like features. When they grow further and connect with each other, the incipient elevated rims of PSSs begin to form. Type 2: Small folds and fractures (thrusts) up to 30 cm apart that have produced polygonal patterns in the salt crust (Fig. 1c) are believed to be caused by the annual expansion of the salt crust due to the growth of salt crystals within the salt layer plus the effect of increased summer temperature. It is suggested that these strain systems are caused by positive (compressional) isotropic pressure stresses developed within the salt layers of the salt crust. Type 3: The drying of small salt ponds commonly produces a salt crust mixed with wind-blown sand or dust eventually resulting in an uneven surface. Comparable size nodular-shaped structures (Fig. 1d) will form across the upper salt crust as the pond evolves. At this stage, intense evaporating will result in the accumulation of salt crystals near the surface by the salt water ascending upward to the surface through the crust fractures, which are produced by sustained growth of salt crystals beneath. At the same time, the salt crystals are cemented with wind-blown materials (sediment). The growth of fracturing causes crust cracks connected with each other to form polygonal structures. Type 4: Desiccation cracks are initially formed by intensive evaporation. Subsequently, the fractured zones become the dynamic place for convection between internal and external systems, leading to the accumulation of salt crystals along the strike of polygonal fractures due to continuous evaporation process (Fig. 1e).

Intermediate stage of PSS evolution. Due to the continuous action of the underground brine, the polygon rims continue to grow, and gradually, become wider and higher (Fig. 1f). Usually we find pore holes and hollows within top salt crust of PSS rims, within which stalactite-like salt crystals are observed, suggesting the upward flow of the brine water below.

Late stage of PSS evolution. As the decreasing of water sources and the lowering of water table level, the evaporation process cannot allow the brine water below to reach the surface. The raised rims stop growing, and are then eroded to varying degree. Dynamic places of the rim zone produce salt solution tubes by convection. No vertical tabular-shaped salt crystals are newly produced, crust surface generates collapses, rims become lower and even partially destroyed and disappear (Fig. 1g). Digging a hole in the rim, we see the subsurface void and a thick weathered sand-dust layer overly-

ing the salt crust, indicating that the growth of the salt crystals in the center fracture has stopped for a period of time.

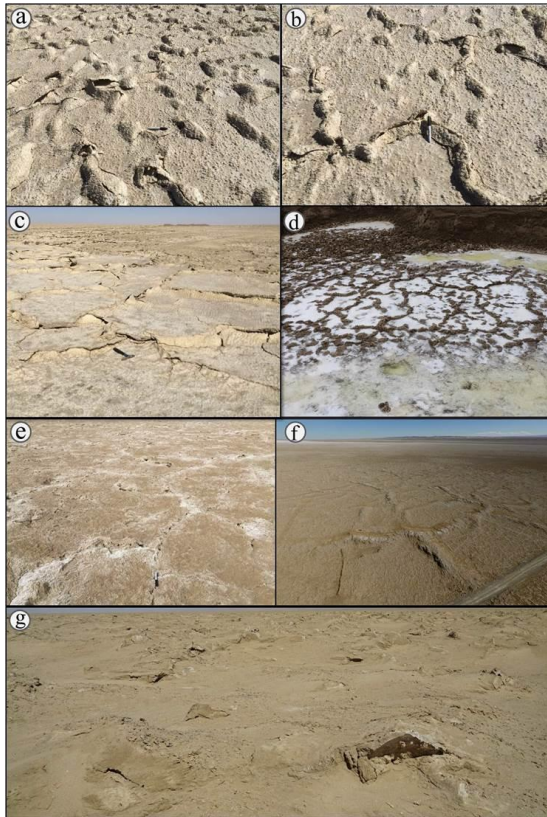


Figure 1 Three stages of the Qaidam basin PSS evolution: (a) Small domes, and fin- or island-like positive features; (b) A doming point and associated two anticlinal folds grow radially at about 120 degrees; (c) Slab bulge and fold; (d) Nodular-shaped structures; (e) White salt deposits along the strike of polygonal fractures; (f) Intermediate stage polygonal fold systems in the salt crust; (g) Collapsed polygon rims with degradation at the late stage of PSS evolution.

Martian PSS morphology as an indicator of the similar development processes: Figure 2 shows morphologically different PSSs detected on the floor of a degraded crater, a northeastern circum-Hellas region on Mars. Cracked crust of white salt sedimentary [11] and raised rims with top summit fractures are observed to coexist [4], suggesting different development stages of Martian salt PSSs (Figs. 2a and b). The advection, vertical convection, and salt diffusion within the porous media minerals are dominantly driven by surface evaporation and subsurface water supply. These endogenous processes are indicated by the presence of layered salt accumulation and growth (precipitation) in and/or along the strike of polygonal (ridge top) fractures. This is consistent with previous laboratory observation of convective movement of salty water and downwelling convective plumes underneath the salt

ridges [1]. On Mars, the fractures are preferentially filled with sand-dust mixtures govern by wind activity. The analysis of these salt PSSs and their development can reveal the processes responsible for their formation, providing important implications for the Martian history of its environmental and climate evolution.

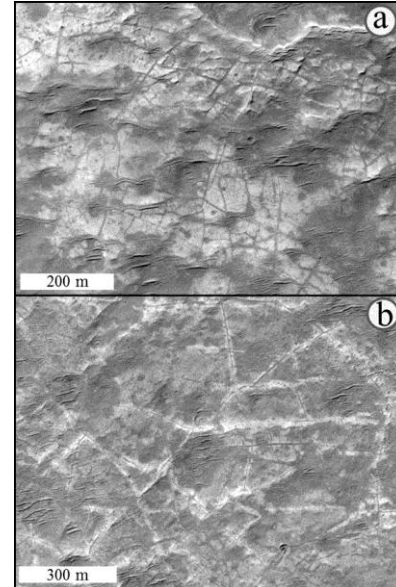


Figure 2 Polygonal cracks (a) and raised rim-polygons (b) in a chloride-bearing highland deposit, northeastern circum-Hellas region on Mars (HiRISE ID: ESP_024922_1570).

Conclusions: Different stages of PSS development are observed both on Earth and Mars (from polygonal cracks to rim ridges). The convection along the crust fractures lead to the formation of rim ridges of PSSs by a combination of thermodynamic and geochemical mechanisms. We continue to analyze more examples to test further the involved processes of the salt PSS development and growth on Mars.

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