Introduction: Whereas surface polygonal patterns are very common on Mars, there is a general tendency in planetary science literature to classify such patterns as products of thermal contraction. This assumption is generally justified by the climatic conditions on Mars that are believed to have been persistent for the past 3 billion years, and the preferential observation of such patterns in the high latitudes where fracture-filling surface ice/frost acts as a visual aid. However, the ever-expanding data set of the Mars Reconnaissance Orbiter High Resolution Imaging Science Experiment (HiRISE) has shown that the surface of Mars is host to various surface cracking patterns that can no longer be explained using a thermal contraction mechanism alone. To that end, we review and present here a synthesis of the collective evidence suggesting that desiccation cracks and polygons (DPs) may be more common on the surface of Mars than previously thought. We also review the state of terrestrial research on desiccation processes with emphasis on the theoretical background, field studies, and modeling constraints.

The process of desiccation: Desiccation is usually achieved through evaporation from the surface, or diffusion processes either through the migration of liquid water caused by differences in water potential, or vapor transport due to changes in water vapor pressure. The depth and spacing of any resulting fractures (i.e., size of polygonal network) depends on many factors, but mainly on the thickness of the stressed zone. As a result, polygons formed by desiccation can be in the order of centimeters if the stressed region is a thin surficial layer undergoing evaporation as for example in the case of common mud cracks, or it can be in the order of hundreds of meters if the stressed region is thick enough because of intense evaporation and/or lowering of the water table [1]. Generally, the more clay-rich the material is, the more it will shrink with desiccation. In addition, certain clay minerals, smectites, are known for their chemical affinity to swell and accommodate considerable amounts of water through formation of water interlayers on a molecular level.

State of Terrestrial research: Detailed field analysis at sites containing large DPs [2] (up to 300 m-wide) has shown that the sediments are remnant lacustrine clays and silts from former lakes. These sediments can often be more than 50 meters thick and are composed of predominantly silt- and clay-rich soils containing clay minerals such as montmorillonite, illite, and vermiculite in addition to carbonates and analcites. These large features were proposed to form through the slow lowering of a water table rather than surface evaporation, which would permit the build-up of stress in thick beds within long time periods (1–2 years).

To test the viability of water table fluctuations in causing large desiccation fractures to develop, numerical models of desiccation are needed. Current models [3] show that tensile stresses rise monotonically with desiccation. Soils with diffusivities below $10^{-4}$ m$^2$/s are
not capable of generating high enough stresses to cause fracturing while high diffusivities (>10^2 m^2/s) lead to shallow cracking (due to high desiccation rates). Intermediate values between 10^-2 and 10^-4 m^2/s, which incidentally fall within the ranges of clay-rich soils [3], create optimum conditions for the formation of cracks at the time scales suggested for the formation of giant DPs on Earth.

**Potential DPs (PDPs) on Mars:** PDPs are a common feature in phyllosilicate- and chloride-bearing terrains [4,5] and have been observed with size scales that range from cm- to 10s of meters-wide using images from HiRISE [e.g., 6,7,8,9,10] and currently active rovers [11] (Fig. 1). The global distribution of PDPs shows that they share certain traits in terms of morphology and geologic setting that can aid in their identification and distinguish them from fracturing patterns caused by other processes (Fig. 2). Most PDPs currently observed attain a size range of 2–30 meter-wide. PDPs are almost exclusively observed in light-toned units with respect to the surrounding terrain. They commonly underlie dark-toned materials, which are often spectrally featureless and display signs of recent exhumation. PDPs are generally flat (lacking raised rims or bulging centers) and usually subdivide extensively to form secondary to multiple generations of cracks in a fractal-like pattern that is embedded within the larger primary polygons and requires images with sub-meter spatial resolution to identify. PDPs are mostly associated with sedimentary deposits that display spectral evidence for the presence of Fe/Mg smectites in addition to Al-rich smectites and less commonly kaolinites, sulfates and carbonates. In contrast, PDPs are uncommon in materials that have been heavily modified by erosion, tectonism, or extensive reworking (e.g., central-peak materials uplifted by impact cratering). Similarly, they are uncommon in materials of possible geothermal or hydrothermal origin, which is inferred from the presence of high-temperature or pressure mineral phases such as chlorites, prehnite and serpentine.

**Implications:** PDPs can be excellent markers for paleolacustrine environments and their presence implies that the fractured units are rich in smectite minerals. Together, the following criteria: 1) detection of Fe/Mg smectites along with salts, carbonates, kaolinite, and possibly illite, 2) absence of high temperature/pressure phases, and 3) association with polygonal patterns resembling DPs make a certain location a high candidate for a paleolacustrine site on Mars, which is a top-priority setting for in-situ exploration and search for paleo-organic materials. The presence of DPs in association with many phyllosilicate exposures that are located in natural basins and/or are of sedimentary origin would argue for a more hydrologically active period and warmer conditions than what is observed today. However, the presence of DPs is similarly consistent with climatic conditions that display only short intermittent hydrological activity characterized by ground-water activity in generally arid conditions.