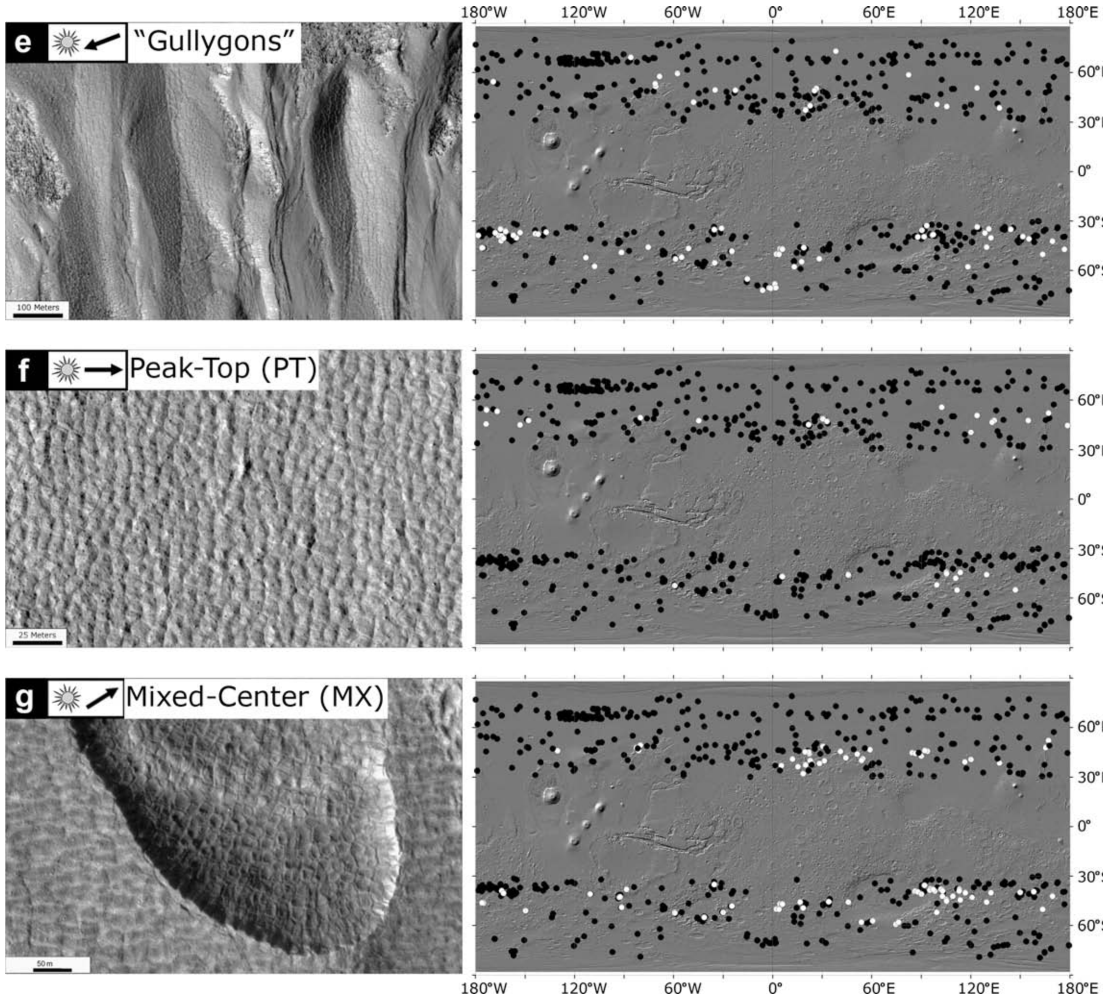

Fig. 1 (*continued*)

2007), and (5) climate record analysis on regional and local scales (Denton et al., 1993, 2002; Sugden et al., 1993; Doran, 1995; Marchant et al., 1996; Doran et al., 2002; Kowalewski et al., 2006; Kowalewski and Marchant, 2007; Swanger and Marchant, 2007) (Fig. 3). It is only through the combined research of workers from a range of permafrost-related disciplines that a complete understanding of the processes, properties, and significance of terrestrial thermal contraction crack polygons has begun to emerge. Accordingly, we first review recent advances in terrestrial thermal contraction crack polygon research in order to provide insight into the range of potential polygon processes observed on Mars. Next, we address the physical processes involved in thermal contraction crack polygon formation, and the efforts to extend our understanding of the critical mechanisms to martian conditions, before linking historical observations of polygonally patterned ground on Mars to recent results from the Mars Reconnaissance Orbiter HiRISE experiment (McEwen et al., 2007a). Finally, we address the future of martian polygon and permafrost investigations by outlining significant outstanding questions and strategies for connecting terrestrial analog research to ongoing planetary exploration.

2. Advances in terrestrial polygon research

Analysis of the morphology and development of polygonally patterned ground across a range of climates and land surfaces on Earth has led to the accumulation of a large body of information that is useful for understanding the origin, significance, and processes operating in martian thermal contraction crack polygons (e.g., Marchant and Head, 2007). Thermal contraction crack polygons represent one end-member landform in the range of "patterned ground" features observed in polar terrains on Earth (e.g., Washburn, 1973; French, 1976). In particular, thermal contraction crack polygons are a form of "non-sorted patterned ground," distinct from sorted circles, nets, and polygons that arrange sediments by surficial freeze–thaw processing (Washburn, 1973). Here, we address the basis for comparisons between thermal contraction crack polygons on Earth and Mars, provide an overview of polygon morphological groups, and address several principle problems in terrestrial polygon research: cracking mechanisms, resurfacing rates and processes, and water transport in polygonally-patterned terrains.

2.1. Advances in thermal contraction cracking

Failure of ice-cemented permafrost in response to stresses generated by thermal contraction has long been implicated in the formation of thermal contraction crack polygons: a process facilitated by the large coefficient of thermal expansion of ice ($\sim 5 \times 10^{-5}$/K) relative to rock ($\sim 5–10 \times 10^{-6}$/K) (Leffingwell, 1915; Péwé, 1959; Lachenbruch, 1962; Hobbs, 1974; de Castro and Paraguassu, 2004) and the relatively low tensile strength of ice (~ 2 MPa) (Hobbs, 1974; Mellon, 1997). Significant progress in modeling thermal contraction cracking was made by Lachenbruch (1962), work that implicated the rapid cooling of a visco-elastic (rather