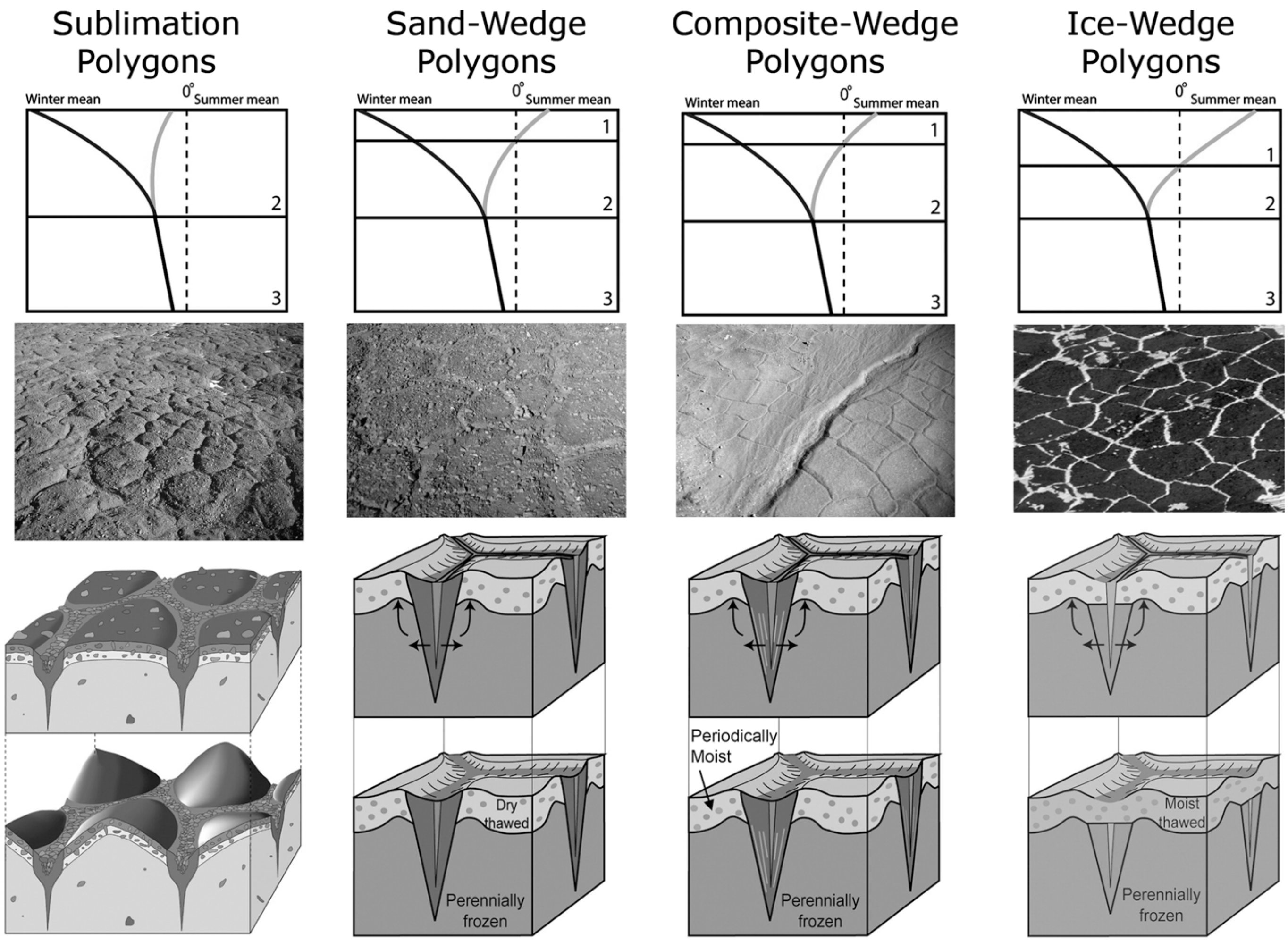


**Fig. 2.** Polygon morphology and surface thermal profiles as a function of microclimate zone in the Antarctic Dry Valleys (adapted from Marchant and Head, 2007). Top (row 1): schematic showing vertical thermal profiles for polygon-forming substrates. Dashed line represents 0 °C (273 K) baseline; dark and light lines show winter-mean and summer-mean soil temperatures as a function of depth, respectively. Numbered soil "horizons" are defined on the basis of temperature profiles. Horizon 1 is a surface layer that experiences summer temperatures above 0 °C (273 K). In the case of ice-wedge polygons in the coastal thaw zone (CTZ) (right), soils are seasonally moist and thus seasonal oscillation about 0 °C (273 K) produces a classic active layer (see text for discussion). For sand-wedge and composite-wedge polygons in the inland mixed zone (IMZ) (center two columns), soils are typically too dry to produce classic active-layer disturbance, even though summer soil temperatures rise above 0 °C (273 K). Horizon 1 is not present for sublimation polygons (Marchant et al., 2002) in the stable upland zone (SUZ) (left) because mean-summer soil temperatures fail to rise above 0 °C (273 K); this zone lacks a traditional active layer. Horizon 2 reflects the depth to which near-surface materials experience seasonal temperature change. Temperature oscillation results in material expansion/contraction and is responsible for the initiation of polygonal terrain. Horizon 3 reflects a zone of uniform temperature increase with depth; the base of the permafrost would occur where temperatures exceed 0 °C. Middle (row 2). Left: oblique-aerial view of sublimation polygons (Marchant et al., 2002) in the SUZ; field of view (FOV) is ~200 m. Center-left: oblique-aerial view of sand-wedge polygons in lower Beacon Valley (Marchant et al., 2002); FOV is ~50 m. Center-right: oblique view of composite-wedge polygons in the IMZ, cross-cut by a seasonally active gully; FOV is ~75 m. Right, oblique-aerial view of ice-wedge polygons in CTZ; FOV is ~75 m. Bottom (row 3): block diagrams illustrating the development of sublimation-type polygons (left), sand-wedge polygons (left-center), composite-wedge polygons (right-center), and ice-wedge polygons (right). Sublimation polygons form in an ice-dominated substrate (Marchant et al., 2002), while sand-wedge, composite-wedge, and ice-wedge polygons typically form in ice-cemented sediment (Marchant and Head, 2007).

than elastic) permafrost layer in the generation of thermal stresses sufficient to overcome the tensile strength of permafrost. This concept has been extensively expanded upon by Mellon (1997, 2008), who applied a refined visco-elastic cracking model to martian conditions (showing that thermal contraction cracking at a range of length scales is expected in martian permafrost under current climate conditions); by Plug and Werner (2001, 2002), who expanded on the details of network development, fracture propagation, and the importance of peak cooling events over mean conditions in establishing fracture network morphology; and by Maloof et al. (2002), who demonstrated the importance of a critical ice content in permafrost that drives a critical viscosity in permafrost necessary to propagate surficial fractures to depth. These theoretical advances underscore the concept that polygon morphology is strongly influenced by surface rheological properties responding to climate conditions (Fig. 2). For example, in Beacon Valley, Antarctica (Sugden et al., 1995; Marchant et al., 2002, 2007; Kowalewski et al., 2006; Kowalewski and Marchant, 2007; Kowalewski, 2009) rheological differences between debris-covered glacier ice (Fig. 4) and ice-cemented sediment produce significant differences in polygon morphology: small (~10–15 m diameter), domical, high-center sublimation polygons (Marchant et al., 2002; Marchant and Head, 2003) form in a debris-covered glacier ice substrate (Sugden et al., 1995; Marchant et al., 2002), while larger (~15–20 m diameter), low-relief sand-wedge polygons form in an ice-cemented sediment substrate (Fig. 4) under identical surface climate conditions (Marchant and Head, 2007).

In addition to enhancements in the modeling of thermal contraction cracking, additional field investigations have demonstrated that variable initiation and propagation behavior of