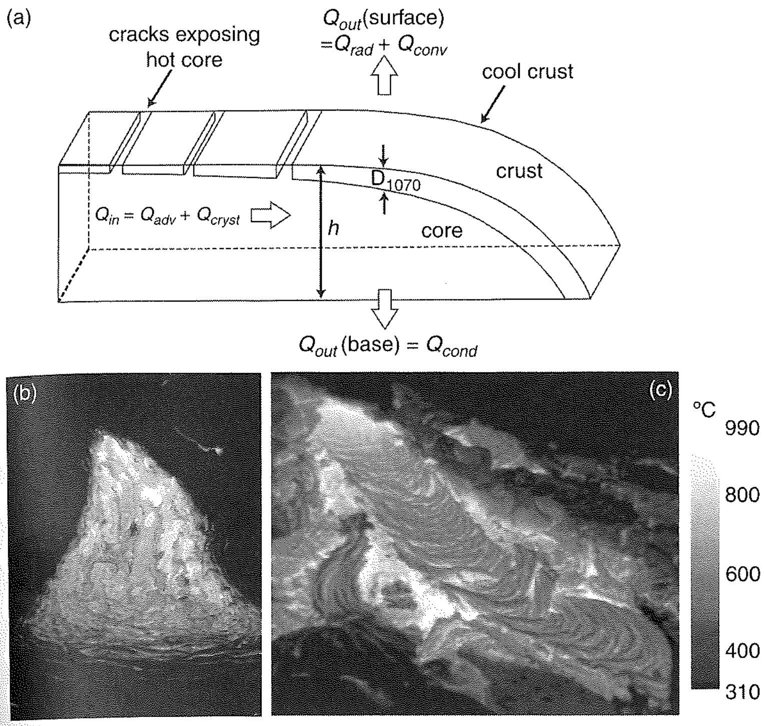

Figure 5.4 (a) Two-component model for the thermal structure of a lava flow surface, showing a chilled crust broken by cracks exposing the hot core, and the main heat sources and sinks (modified from Fig. 3 of Crisp and Baloga (1990)). (b) Photograph of a pahoehoe breakout (~1 m wide) showing at least three thermal components apparent from the different colors; yellow (~1090 °C), bright orange (~900 °C), dull orange (550–700 °C) and black (< 475 °C). (c) Thermal image of pahoehoe channel (central ropey slab is ~2 m wide and 5–6 m long) showing active surfaces ranging in temperature from ~400–1000 °C, with lower temperatures marking older, cooler crust developing on the flow surface as it advances and ages. See color plates section.

core temperature of 1140–1150 °C (Hon *et al.*, 1994), meaning that maximum surface temperatures measured at Hawaiian pahoehoe are typically ~1000 °C. Likewise, maximum surface temperatures measured at a lava channel on Mt. Etna (Italy) within 70 m of the vent were typically 730–1040 °C (mean of 880 °C) compared with a core temperature of 1065 °C (Harris *et al.*, 2005; Bailey *et al.*, 2006). Thus, use of a value for T_{core} that is offset from the true core temperature may yield more realistic values of T_e. In addition, more than one thermal component may be present on the flow surface (Figs. 5.4(b), 5.4(c)). Wright and Flynn (2003) found that active pahoehoe surfaces were best modeled using between five and seven thermal components at temperatures ranging between 200 and 1000 °C. In comparison, thermal data from active lava channels indicate that a four thermal component model may be used to describe such surfaces (see Exercise 5.1; online resources listed at end of chapter).

Convective heat loss from a flow surface involves heat transfer to an overlying gas or fluid. There are two cases. Free convection occurs in still conditions and can be conceptualized in terms of a heated plate exposed to ambient room air without an external source of motion (i.e., no wind). Heating of the air from beneath causes the air to expand. The subsequent reduction in density causes the heated air to become buoyant so that it rises, carrying heat with it and away from the surface. In contrast, forced convection is the cooling effect experienced when cool air blows over a hot surface. Both can be described in terms of the convective heat transfer coefficient, h_c:

$$q_{conv} = h_c\,(T_{surf} - T_a), \tag{5.17}$$

where q_{conv} is the convective heat flux (in W m^{-2}), and multiplying by the area, A, of the hot surface gives the total convective heat loss, Q_{conv}, in watts. The convective heat transfer coefficient, h_c, can be calculated theoretically (as in Exercise 5.2; online resources listed at end of chapter), but differs for free and forced convection and varies with wind speed. However, values of between 5 and 150 W m^{-2} K^{-1} appear appropriate for subaerial active lavas (Keszthelyi and Denlinger, 1996; Neri, 1998; Keszthelyi *et al.*, 2003).