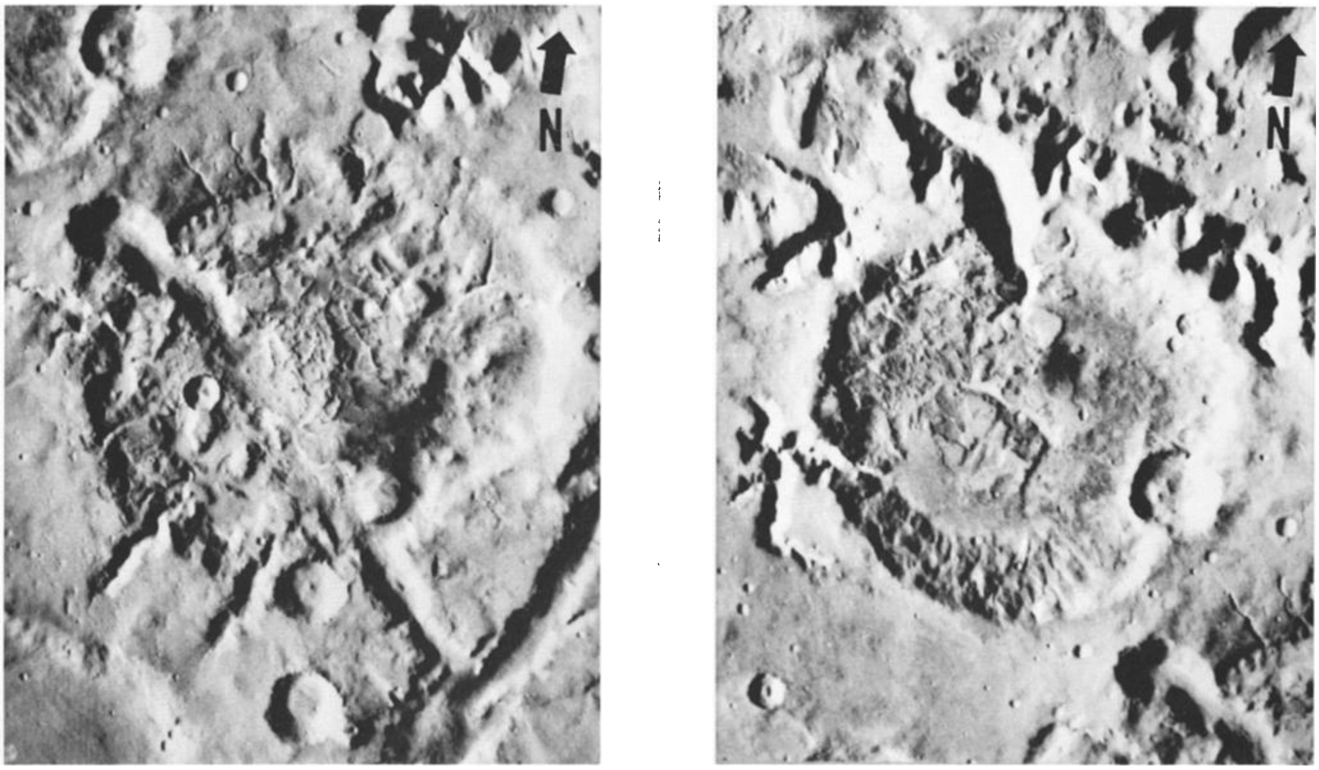

a b

Fig. 6. (*a*) Heavily degraded 60-km-diameter crater in cratered plains near Utopia Planitia northwest of Isidis Planitia. The crater rim has been completely destroyed or buried prior to more recent modification characterized by deeply cut radial valleys extending beyond the crater rim. A deep canyon crosses the crater floor and connects with fault-controlled canyons extending to nearby low-lying plains. Narrow ridges in the central region resemble the system in Figure 5. Viking frame 534A47 centered at 285°W, 27°N. (*b*) Degraded 70-km-diameter crater adjacent to example in Figure 6*a*. The northwestern crater floor exhibits ridged and furrowed terrain resembling the crater floor in Figure 6*a*. The northern crater floor displays irregular plateaus and small circular mesas. The southern floor contains smooth plains material and resembles numerous other unmodified craters in the region. A deep canyon breaches the northern rim and appears to provide a channel for removed floor materials. Viking frame 534A26 centered at 286°W, 29°N.

generally are concentrated near Valles Marineris, volcanic plains, and the fretted terrains [*Schultz,* 1978]. Additionally, many examples are found in the 'cratered plains' and 'cratered plateau' materials mapped by *Scott and Carr* [1978] and interpreted as an early stage of flood lavas by *Wilhelms* [1974] and *Greeley and Spudis* [1978].

Such diverse styles may reflect different regional histories prior to modification, different sizes or depths of the intrusive body, different degrees of thermal interaction between the intrusion and ice-bearing material or hygroscopic minerals, and/or different styles of release of hydrothermal materials. Further consideration of these alternatives is deferred to a subsequent section.

INTRUSIVE MELTING OF CRATER-TRAPPED WATER-ICE

Various studies have suggested that local geothermal heat associated with intrusives may have contributed to local melting and/or deterioration of ground water-ice [*McCauley et al.,* 1972; *Milton,* 1973; *Sharp,* 1973; *Masursky et al.,* 1977; *Schultz,* 1978; *Soderblom and Wenner,* 1978; *Schultz et al.,* 1979] or hygroscopic minerals [*B. C. Clark,* 1978]. The preceding section suggests that such intrusions may be localized beneath modified impact craters. The following discussion considers the possible thermal effect of crater-controlled intrusions on overlying ice-bearing material.

The theoretical cooling history of a mafic intrusion has been derived by *Jaeger* [1964]. In his model, the magma is emplaced instantaneously (a reasonable approximation for terrestrial intrusions) and loses its heat to the country rock only by conduction. Cooling by conduction only is knowingly an oversimplification, but such an assumption provides a lower limit for the model. For a constant volumetric specific heat in the system we can derive from Jaeger's analysis the amount of heat transferred from a sill to a unit volume of the surrounding country rock at a temperature T_c over a given time:

$$H = (\rho c)(T_0{}^* - T_c)\left(\frac{4\pi K t}{s\rho c}\right)^{-1/2} \exp\left[-\left(\frac{x^2\rho c}{4Kt}\right)\right] \quad (1)$$

where (ρc) is the volumetric specific heat; $T_0{}^* = T_0 + L/c$ includes the original temperature, T_0, of the magma, the latent heat of the magma, L, and specific heat of the magma, c; K is the conductivity of the country rock; s is the thickness of the intruded sill; x is the distance from the center of the sill; and t is the time. Over infinite time, this equation provides the maximum heat added to a unit volume of the country rock at a given distance from the intrusion:

$$H_{max} = (0.242)(\rho c)(T_0{}^* - T_c)s/x \quad (2)$$

Equations (1) and (2) are valid only for regions beyond $x > s$ from the center of the intrusion. Moreover, the volumetric