



Fig. 2a

Fig. 2. Two Martian volcanoes on the northwest edge of Tharsis Montes partially buried by younger volcanic deposits. (a) Biblis Patera (2°N , 124°W). Lava flows from sources other than the central caldera have flooded around the base of the volcano, often truncating the northwesterly trending graben. Viking Orbiter frame 44B50, width 175 km. (b) Ulysses Patera (3°N , 122°W). Lava flows also have flooded the base of this volcano, reducing its relative relief. A graben extending across the volcano from the northwest has been flooded at its intersection with the surrounding plains to the southeast. The two central-peaked impact craters on the volcano flank and rim have had their ejecta deposits buried by later lava flows on the exterior flanks of the volcano. Viking Orbiter frame 49B85, width 175 km.

larger craters on underlying surfaces [e.g., *Wise et al.*, 1979a]. In spite of these many uncertainties, the low densities of impact craters on the most recent volcanic flows in the Tharsis region indicate geologically young ages by all the current crater chronologies [*Neukum and Wise*, 1976; *Soderblom*, 1977; *Hartmann*, 1977]. The youngest surfaces on Olympus Mons and related flows, for instance, have ages estimated to be in the range 25 to 250 m.y. [*Schaber et al.*, 1978; *Plescia and Saunders*, 1979b]. Thus volcanism in the Tharsis area has extended over a time span of almost 4 billion years, or most of the history of Mars.

Important but poorly constrained quantities are the total volume of volcanic material in the Tharsis province and the volcanic flux through time. The volumes of the large shields are known from their topographic relief [*Carr*, 1973; *Blasius*

and *Cutts*, 1976, 1981]. The volumes of a number of prominent flows have been estimated by *Scott and Tanaka* [1980] from the flow areas and an assumed value of 200 m for the average thickness of a flow unit, a value estimated from the observation that craters 5 km in diameter were often incompletely buried by flow units. The thicknesses of major volcanic units in the Tharsis area have also been estimated by *Plescia and Saunders* [1980] and *De Hon* [1981] from the inferred rim heights of partially buried large (10- to 60-km diameter) craters. On this basis, *Plescia and Saunders* [1980] obtain a combined thickness of 0.5 to 0.6 km for the cratered plains and Tharsis plains in southern, southwestern, and northeastern portions of the Tharsis province. The results of *De Hon* [1981] are in agreement for these units; *De Hon* further inferred thicknesses of 0.7 to 1.3 km for the ridged