



but it has been suggested that due to the probable chemical composition of the mantle, Mars may have expanded slightly as the interior cooled. The top of this uplifted region is marked by numerous intersecting graben-like troughs (in the Labyrinthus Noctis area) and is the centre of a vast system of radial fractures, some of which extend for thousands of kilometres. These are particularly important on the eastern side, where they have apparently led to the formation of the immense Vallis Marineris canyon system, which is several kilometres deep and extends for about 4 000 km across the planet, roughly parallel to the equator. At its eastern end it joins the Chryse Trough which runs from south to north across the cratered upland terrain.

The Chryse Trough contains the major part of the so-called **chaotic terrain** where irregular depressions are filled with an apparently haphazard arrangement of blocks ranging in size from tens of kilometres to a few hundreds of metres. In this area there is no distinct drainage, but further downslope, sinuous river-like channels run down on to the Chryse Plain (the landing site of Viking 1) and thus reach the northern plains (*below left*). These channels greatly resemble those formed by intense flooding of arid areas on Earth and are found in other parts of the cratered terrain, close to the boundary with the northern plains.

Water and wind action

Present conditions on Mars do not permit rainfall or areas of liquid water to occur and it is a matter of debate whether they could ever have been present. It is possible, however, that the early, fairly dense atmosphere contained considerable quantities of water vapour and that as the planet cooled this was taken up by the surface materials to form kilometre-thick layers of ground ice. Subsequently, tectonic movements and fracturing, impact cratering or volcanic heat could either expose the ice and cause it to sublime (turn directly to water vapour) or, in some cases, produce the short-lived but vigorous flooding which led to the formation of the channels. Slumping of surface materials following removal of ground ice would lead to the typical chaotic terrain, and study of the Vallis Marineris area shows that fracturing initiates the formation of chains of small pits. These gradually grow and eventually form the vast canyons that we see.

Destruction of ground ice would lead to a smaller volume of solid debris than might otherwise be expected, but the almost complete lack of sedimentary deposits associated with the various depressions almost certainly indicates removal of the small particles by wind action. There is ample evidence for such transport of fine materials in the numerous light and dark streaks which can be seen, as well as in the changes of some of the surface markings. Moreover, the recurrent alterations in the dark features appear to be due to seasonal variation in the pattern of surface winds.

Areas of dunes are visible and similar small features are shown by Viking Lander 1 pictures (pages 130–131).