**The Surface of Mars**

**火星表面**

The surface of Mars shows a wide range of geologic features, including huge volcanoes—the largest known in the solar system—and extensive impact cratering. Three very large volcanoes are found on the Tharsis bulge, an enormous geologic area near Mars’s equator. Northwest of Tharsis is the largest volcano of all: Olympus Mons, with a height of 25 kilometers and measuring some 700 kilometers in diameter at its base. The three large volcanoes on the Tharsis bulge are a little smaller—a “mere” 18 kilometers high.

火星表面展示了很多种地理特征，包括巨大的火山——太阳系中已知的最大火山——以及覆盖范围很广的陨石坑。塔尔西斯高原是火星赤道附近的广阔地质区域，在这里发现了三座非常大的火山。位于塔尔西斯西北的奥林帕斯山是其中最大的一座火山：25千米高，测得其基部直径大约有700千米。位于塔尔西斯高原的三座大火山则略矮，高度“仅”达18千米。

None of these volcanoes was formed as a result of collisions between plates of the Martian crust—there is no plate motion on Mars. Instead, they are shield volcanoes—volcanoes with broad, sloping slides formed by molten rock. All four show distinctive lava channels and other flow features similar to those found on shield volcanoes on Earth. Images of the Martian surface reveal many hundreds of volcanoes. Most of the largest volcanoes are associated with the Tharsis bulge, but many smaller ones are found in the northern plains.

这些火山都不是因火星表面的板块碰撞而形成的——火星上并无板块运动。这些火山其实是盾状火山——一种由熔岩形成的斜面宽阔并且坡度平缓的火山。上述4座火山都具有非常明显的熔岩隧道以及其他流动特征，这与地球上的盾状火山相似。火星表面的图像显示那里存在成百上千的火山。那些最大的火山中的大部分都与塔尔西斯高原有关，但是很多稍小的火山都分布在北部平原地区。

The great height of Martian volcanoes is a direct consequence of the planet’ slow surface gravity. As lava flows and spreads to form a shield volcano, the volcano’s eventual height depends on the new mountain’s ability to support its own weight. The lower the gravity, the lesser the weight and the greater the height of the mountain. It is no accident that Maxwell Mons on Venus and the Hawaiian shield volcanoes on Earth rise to about the same height (about 10 kilometers) above their respective bases—Earth and Venus have similar surface gravity. Mars’s surface gravity is only 40 percent that of Earth, so volcanoes rise roughly 2.5 times as high. Are the Martian shield volcanoes still active? Scientists have no direct evidence for recent or ongoing eruptions, but if these volcanoes were active as recently as 100 million years ago (an estimate of the time of last eruption based on the extent of impact cratering on their slopes), some of them may still be at least intermittently active. Millions of years, though, may pass between eruptions.

火星上火山的可观的高度是该行星(相对)较低的地表重力导致的直接结果。当熔岩流淌和蔓延以形成盾状火山时，这座火山的最终高度取决于这座新生的山承载自身重量的能力。重力越低，重量就越小，山的高度就越高。如金星上的麦克斯韦山与地球上的夏威夷盾状火山从它们各自的基部算起海拔高度相同(大约10千米高)，这不是什么巧合——地球与金星的地表重力相当。火星表面重力只有地球的40%，因此火星上的火山高度大致是地球的2.5倍。火星上的盾状火山是否还处于活跃期?科学家们没有直接证据显示这些火山近期是否喷发过，或是否正处于喷发阶段，但是如果这些火山近期的活跃状态一如一千万年前那般(这一最近的爆发期是根据火山斜坡上陨石坑的范围估算出来的)，它们当中的几个也许至少仍然会保持间歇性的活跃。然而，两次爆发之间也许间隔数百万年之久。

Another prominent feature of Mars’s surface is cratering. The Mariner spacecraft found that the surface of Mars, as well as that of its two moons, is pitted with impact craters formed by meteoroids falling in from space. As on our Moon, the smaller craters are often filled with surface matter—mostly dust—confirming that Mars is a dry desert world. However, Martian craters get filled in considerably faster than their lunar counterparts. On the Moon, ancient craters less than 100 meters across (corresponding to depths of about 20 meters) have been obliterated, primarily by meteoritic erosion. On Mars, there are relatively few craters less than 5 kilometers in diameter. The Martian atmosphere is an efficient erosive agent, with Martian winds transporting dust from place to place and erasing surface features much faster than meteoritic impacts alone can obliterate them.

火星表面的另一个突出特征是陨石坑。水手计划中的宇宙飞船发现，在火星表面布满来自太空的流星撞击表面形成的陨石坑，火星的两颗卫星也是如此。与我们的月球类似，那些较小的陨石坑经常被一些物质填满(主要是灰尘)，这表明火星是一个干燥的沙漠世界。然而，与月球相比，火星上的陨石坑被填满的速度明显要快很多。在月球上，那些直径不足100米(对应深度大约在20米)的古老陨石坑主要被流星冲击而形成的尘埃填平了。而在火星上，只有相当少的一部分陨石坑直径小于5千米。火星大气是一种强效的腐蚀剂，加之火星上的风把灰尘从一个地方卷到另一个地方，(火星上的)地表特征被消除得更快，比仅仅依靠流星冲击要快得多。

As on the Moon, the extent of large impact cratering (i.e. craters too big to have been filled in by erosion since they were formed) serves as an age indicator for the Martian surface. Age estimates ranging from four billion years for Mars’s southern highlands to a few hundred million years in the youngest volcanic areas were obtained in this way.

与在我们的月球上相同，那些巨大陨石坑的范围(例如，那些巨大到自形成后尚未被尘埃填满的陨石坑)充当着火星表面年龄指示器的角色。从火星南部高地的40亿年至最年轻的火山地区的几千万年都是用同样的方法估算的。

The detailed appearance of Martian impact craters provides an important piece of information about conditions just below the planet’s surface. Martian craters are surrounded by ejecta (debris formed as a result of an impact) that looks quite different from its lunar counterparts. A comparison of the Copernicus crater on the Moon with the (fairly typical) crater Yuty on Mars demonstrates the differences. The ejecta surrounding the lunar crater is just what one would expect from an explosion ejecting a large volume of dust, soil, and boulders. However, the ejecta on Mars gives the distinct impression of a liquid that has splashed or flowed out of crater. Geologists think that this fluidized ejecta crater indicates that a layer of permafrost, or water ice, lies just a few meters under the surface. Explosive impacts heated and liquefied the ice, resulting in the fluid appearance of the ejecta.

火星表面陨石坑的具体外貌为揭示该行星表面状况提供了非常重要的信息。火星陨石坑周边布满了喷出物(因撞击而形成的碎片)，这与月球上的陨石坑看起来非常不同。对比月球上的哥白尼陨石坑与火星上(相当典型的)尤蒂陨石坑可以看出不同。月球上陨石坑周边的喷出物正如我们以为的那样，一场爆炸喷出的大量的灰尘、土壤和岩石。然而，火星(上的陨石坑周边的)喷出物则因飞溅而出或溢出的液体给人留下了深刻的印象。地质学家认为这种具有流体化喷出物的陨石坑指示了在火星地表下几米处存在永冻土层或水冰。爆炸性的撞击加热并液化了这些冰，结果导致这些喷出物呈现流体状的特征。